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Review Article

Nutrition and physical activity interventions for the general population with and without cardiometabolic risk: a scoping review

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Abstract

Objective: The objective of this scoping review was to examine the research question: In the adults with or without cardiometabolic risk, what is the availability of literature examining interventions to improve or maintain nutrition and physical activity-related outcomes? Sub-topics included: (1) behaviour counseling or coaching from a dietitian/nutritionist or exercise practitioner, (2) mobile applications to improve nutrition and physical activity and (3) nutritional ergogenic aids.
Design: The current study is a scoping review. A literature search of the Medline Complete, CINAHL Complete, Cochrane Database of Systematic Reviews and other databases was conducted to identify articles published in the English language from January 2005 until May 2020. Data were synthesised using bubble charts and heat maps.
Setting: Out-patient, community and workplace.
Participants: Adults with or without cardiometabolic risk factors living in economically developed countries.
Results: Searches resulted in 19 474 unique articles and 170 articles were included in this scoping review, including one guideline, thirty systematic reviews (SR), 134 randomised controlled trials and five non-randomised trials. Mobile applications (*n* 37) as well as ergogenic aids (*n* 87) have been addressed in several recent studies, including SR. While primary research has examined the effect of individual-level nutrition and physical activity counseling or coaching from a dietitian/nutritionist and/or exercise practitioner (*n* 48), interventions provided by these practitioners have not been recently synthesised in SR.
Conclusion: SR of behaviour counseling or coaching provided by a dietitian/nutritionist and/or exercise practitioner are needed and can inform practice for practitioners working with individuals who are healthy or have cardiometabolic risk.

Keywords
Diet
Exercise
Scoping review
Dietitian
Nutritionist
Counseling
Mobile applications

For individuals living in economically developed environments, rates of non-communicable diseases associated with overnutrition, such as type 2 diabetes mellitus and many forms of heart disease, are serious concerns[1]. In addition to the decreasing quality of life[2] and potential lifespan[3], these diseases collectively contribute to extreme economic burdens to the individual and society as a whole[3]. Nutrition and physical activity are each independent risk factors for the development of cardiometabolic diseases and associated mortality[4]. Despite knowledge of the benefits of improved dietary intake and physical activity, three quarters of Americans follow an eating pattern low in fruits and vegetables[5] and only half of adults meet the minimum aerobic physical activity recommendations[6].

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Population-level improvement of nutrition and physical activity behaviours may decrease development and progression of cardiometabolic disease. This may, in turn, result in improved quality of life and a decreased burden of personal and national health care costs. To improve health behaviours on a population level, evidence-based guidance is needed to inform nutrition and physical activity practitioners working with clients in the community, workplace or out-patient settings.

The aim of a scoping review is to map the availability of research, both systematic reviews (SR) and guidelines as well as controlled trials, in areas of interest to determine where resources are available to guide practice, and where evidence is still needed[7]. Additionally, a scoping review can identify which current topics still require SR and evidence-based practice guidelines to inform practitioners working with individuals who are healthy or who have cardiometabolic risk factors. This scoping review was conducted to determine if current evidence was available on relevant nutrition and physical activity interventions for the general population. Specific areas of interest that require clarification or are important to policy or practice were identified by practitioners currently working with clients in the field and are addressed in the individual research questions.

The objective of this scoping review is to address the overarching research question: In adults in the 'general population', including non-athletes or recreational athletes with or without cardiometabolic risk factors, what is the extent, range and nature of literature examining interventions to improve or maintain nutrition and physical activity and related outcomes? Specific research questions examined availability of research describing:

Question 1 (Q1). Individual-level nutrition and physical activity counseling or coaching provided by a dietitian/nutritionist and/or exercise practitioner;
Question 2 (Q2). Mobile applications (apps) and/or wearable technology;
Question 3 (Q3). Nutritional ergogenic aids of interest.

Methods

This scoping review was conducted with the framework introduced by Arksey and O'Malley[8] and developed by Levac *et al.*[9] and the Joanna Briggs Institute[7]. This scoping review was registered on Open Science Framework (osf.io/pc6sy)[10] and adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist for scoping reviews[11].

Eligibility criteria

A full description of eligibility criteria can be found in Table 1. The target population for this scoping review was adults in the 'general' population living in economically developed countries, such as the USA[12]. The authors recognised that currently, a 'general' population does not imply a 'healthy' population, since cardiometabolic risk factors may exist in a majority of adults. Thus, this scoping review included individuals with no risk, risk for and diagnosed with cardiometabolic disease.

Three areas of nutrition and physical activity interventions were explored in this scoping review: (1) counseling or coaching, (2) mobile applications and (3) nutritional ergogenic aids. Q1 examined the efficacy of nutrition and physical activity counseling or coaching provided by a dietitian/nutritionist and/or exercise practitioner (see Table 1 for specific criteria). For Q1 inclusion, study participants must have received at least some individual-level counseling in nutrition and/or physical activity. Q2 explored the efficacy of mobile apps and other wearable technology in nutrition and physical activity interventions. For these two questions, studies were required to be controlled trials, either randomised controlled trial (RCT) or non-RCT. Q3 examined efficacy nutritional ergogenic aids deemed as commonly used in the 'general' population (Table 1). For Q3 only (nutritional ergogenic aids), studies were required to be placebo-controlled RCT. Additionally, for Q3, studies were limited to those reporting anthropometric, body composition and performance outcomes. For all questions, primary studies were included if they were published in 2005 or later to balance a wide breadth of evidence with relevancy of interventions to the current population. SR answering at least one of the research questions were included if published in 2015 or later, since SR published earlier than 2015 may require updated information. Included studies were limited to those published in the English language due to resource constraints.

Search plan

Search strategies were written by an Information Specialist for the following databases via the Ebsco interface: Medline Complete, CINAHL Complete, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials and Food Science Source. Searches were run on 4 and 5 May 2020. Two methodological filters were used, one for SR and meta-analyses, and another observational and other study designs. Results were limited to English language and publication year 2005 forward. Results were managed and deduplicated in Endnote Software. A sample search strategy can be found in online supplementary material, Supplemental 1.

Study selection and data extraction

Article screening was conducted in two phases. In the first phase, each title/abstract was reviewed by at least one reviewer (M.R.) and 22·4 % of title/abstracts were reviewed by a second reviewer (A.Y.) using Rayyan screening software[13]. Any discrepancies between authors were discussed until consensus was reached. Communication

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Table 1 Eligibility criteria for studies including in scoping review examining effect of nutrition and physical activity interventions in the general population

	Inclusion criteria	Exclusion criteria
Peer-review status	Peer-reviewed and published in a juried publication in a peer-reviewed section within the publication	Non-peer-reviewed articles, such as government reports, grey literature

Population	• Humans
	• Adults (≥18 years old)
	• Non- or recreational athletes (<10 h training/week)
		• Animal studies
		• <18 years old
		• Elite athletes (>10 h training/week)
		  • Highly trained
		  • Well-trained
		  • Wrestling, soccer or other team sports

Setting	Out-patient, community	In-patient
Health status	• No diagnosed cardiometabolic diseases or mental health disorder • At risk for or diagnosed with non-acute cardiometabolic disease • Non-severe anxiety or depression • Non-alcoholic fatty liver disease • Osteoarthritis • Sarcopenia	Persons with medical conditions that limit their generalisability to the general population, such as • Acute, terminal or critical illnesses • Dialysed or post-organ transplant • Post-surgical patients • Chronic diseases such as COPD or HIV/AIDS • Spinal cord injury • Cancer or studies targeting cancer survivors • Heart failure, stroke • Pregnancy, lactation, postpartum • Morbidly obese (BMI >/= 40) or who have PCOS; bariatric surgery • Active military • IBD • Severe and persistent mental illness • Institutionalised (nursing home, hospitalised, prison)

Interventions/exposures	• Q1: Nutrition AND exercise counseling or coaching
	• Q1: Must include some individual-level counseling or coaching
	• Q1: Counseling or coaching must be provided by at least one of the following: Dietitian, Diet Tech, Nutritionist (if in country where this is dietitian-equivalent), Health Coach, Personal Trainer, Exercise Practitioner Otherwise Specified
	• Q1: Nutrition counseling topics could include
	  ○ Increased consumption of fruits, vegetables, whole grains, fat-free or low-fat dairy, and lean proteins
	  ○ Limited consumption of Na, saturated fat, *trans*-fat, and sugar-sweetened food and beverages
	  ○ Balanced diet plans such as Mediterranean, DASH, MyPlate
	• Q1: Physical activity coaching could include
	  ○ Aerobic activities that involve repeated use of large muscles, such as walking, cycling and swimming
	  ○ Resistance training designed to improve physical strength
	  ○ Reduction of sedentary behaviours
	  ○ Optional or access to guided physical activity or exercise classes allowed
	• Q2: Wearable technology and/or mobile application (app) to assess and intervene in nutrition AND physical activity
	• Q3: Nutritional ergogenic aids including carbohydrate replacement, caffeine, branch-chained amino acids, creatine, collagen, multivitamins, *n*-3 fatty acids and exogenous ketones
		• Q1: Counseling or coaching for nutrition OR physical activity only
		• Q1: Group level counseling or coaching only
		• Q1: Counseling or coaching provided by: Physician, Nurse, Psychologist, Community Health Worker, Paraprofessional/Peer, any other provider not specified for included
		• Q1: Nutrition counseling topics could not include special/controlled diets (e.g., low-carbohydrate diet)
		• Q1: PA interventions excluded
		  ○ Physical activity counseling solely focused on balance, flexibility or gait
		  ○ Stress management interventions (e.g., meditation or yoga or tai chi-based interventions that have minimal aerobic or strength-building activities)
		  ○ Counseling interventions aimed at fall prevention, cognitive functioning
		• Q1 and Q2: Interventions or exposures that do not consider the combination of nutrition AND physical activity
		• Q3: Dietary supplements other than those indicated. BCAA metabolites

Table 1 *Continued*

	Inclusion criteria	Exclusion criteria
Comparators	Must have a comparison group that is a true control not receiving the intervention. Includes usual care, minimal intervention, attention control no intervention Q3: Placebo controlled	No comparison group. Comparison group is an alternative intervention, with no true control Q1: Comparison group includes counseling or coaching for nutrition only or physical activity only. Comparison group receives only group counseling for nutrition and physical activity Q3: Not placebo controlled
Study design preferences	Systematic reviews and evidence-based practice guidelines Controlled clinical trials (RCT, non-RCT) Q3: RCT only	Narrative reviews, commentary/letters to the editor, case studies Observational studies, including cross-sectional studies, cohort studies Q3: Non-RCT
Minimum study duration	No limits	No limits
Size of study groups	≥10 participants/group	<10 participants/group
Study drop-out rate	No limits	No limits
Outcomes	Q1–Q2: Diet and physical activity (behaviour), intermediate and health outcomes Q3: Physical activity, anthropometric and body composition Intermediate outcomes: Dietary intake, physical activity, body composition (FM, FFM, BMD), anthropometrics, glucose homoeostasis measures/ pre-diabetes, BP, lipid profile, intermediate CVD measures (e.g., intima media thickening), CRP Intermediate outcomes must be measured before and after the trial Health outcomes: mortality, quality of life, CVD/events, type 2 diabetes, metabolic syndrome, malnutrition (overweight/obesity/underweight), anxiety disorders, depression, osteoarthritis, osteoporosis/osteopenia, joint pain	Outcomes other than those specified. Studies examining kinetics only Q3: Outcomes other than physical activity, body composition or anthropometrics
Year range	Primary studies: 2005–4 May 2020 Systematic reviews/meta-analyses: 2015 – May 4, 2020	Primary studies: Prior to 2005 Systematic reviews: Prior to 2015
Language	Published in English language	Not published in English language
Location	Countries with developed economies	Countries that are not economically developed[12]

BCAA, branched chain amino acid; BMD, bone mineral density; BP, blood pressure; COPD, chronic obstructive pulmonary disease; CRP, C-reactive protein; FFM, fat-free mass; FM, fat mass; IBD, irritable bowel disease; PCOS, polycystic ovarian syndrome; Q1, Question 1; Q2, Question 2; Q3, Question 3; RCT, randomised controlled trial.

between reviewers throughout the screening process solidified eligibility criteria. Included title/abstracts moved to the second phase of the full-text review. Prior to the full-text review, authors collaborated to create a template allowing for standardised data extraction and coding, including but not limited to: study design, sample size, population age group, activity level, health status, research question addressed including details specific to the research question (e.g., practitioner delivering the intervention for Q1) and outcomes reported. One of two reviewers (M.R. or A.Y.) reviewed the full text, determined eligibility and extracted data for included articles. The second reviewer confirmed reason for exclusion or checked accuracy of extracted data. Relevant SR were searched for eligible articles that may have been missed by the databases search.

Synthesis of results

The study selection process was documented using a PRISMA flow chart[14]. Data were analysed according to the specific research question addressed and types of studies included. A bubble chart was created to demonstrate publication trends according to the sub-question addressed. For each of the three questions, a heat map was created to demonstrate density of interventions according to the population, type of intervention and/or outcomes reported. As is customary for scoping reviews, critical appraisal of study quality and meta-analyses were not conducted.

Results

The databases and hand searches identified 19 474 unique articles. Following title/abstract screening, 657 full texts were reviewed, and 170 articles answering at least one of the research questions were included in this scoping review (Fig. 1). Eighty-three of the eighty-nine articles not meeting population criteria were specifically excluded for including participants with BMI $\geq$ 40 kg/m^2. Of the articles included, one was an evidence-based practice

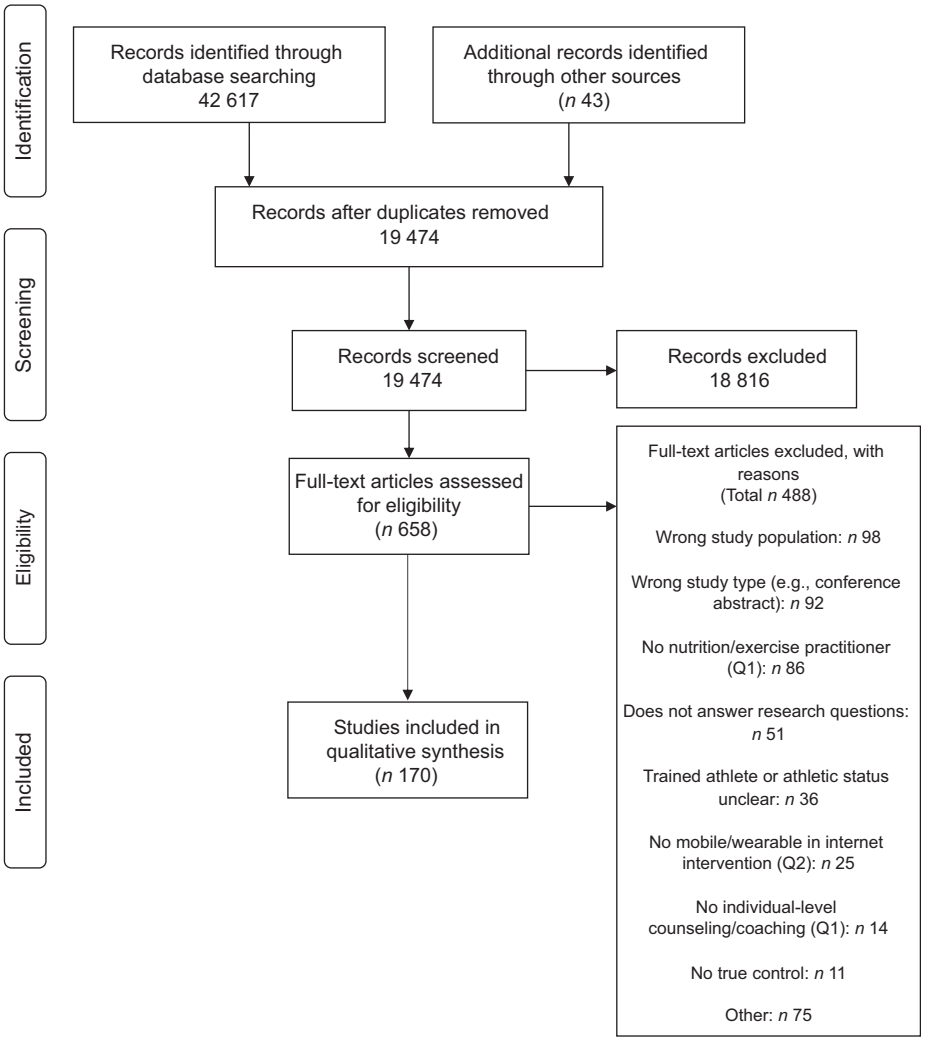

Fig. 1 PRISMA flow chart[14] describing the study inclusion process for a scoping review examining the availability of studies with interventions including both nutrition and physical activity in the general population

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guideline[15], thirty were SR[16–45], 134 were RCT[46–179] and five were non-RCT[180–184]. Forty-eight of the articles were included for Q1 (counseling and coaching), thirty-seven articles were included for Q2 (mobile apps and wearables) and eighty-seven articles were included for Q3 (nutritional ergogenic aids of interest). While the rate of publication was relatively constant over the study period for articles examining nutrition and physical activity counseling and coaching (Q1), the number of primary research articles (not including SR) examining the effects of nutrition and physical activity mobile apps and/or wearables as well as nutritional ergogenic aids of interest grew considerably from approximately 2015–2020 (Fig. 2).

Question 1: Individual-level nutrition and physical activity counseling or coaching provided by a dietitian/nutritionist or exercise practitioner

Forty-eight articles[15,32,46,47,49,51,52,56,69,74,76,78,83,89–91,101–104,108,109,111,120,121,128,130,133,138,139,142,147–151,154,157,160–162,169,171,172,177,180,182,184] representing thirty-eight studies met inclusion criteria and examined the effect of nutrition and physical activity counseling or coaching from a dietitian/nutritionist or exercise practitioner, including one evidence-based practice guideline, one SR, thirty-three RCT and three NRCT. The populations, intervention providers and reported outcomes are shown in Table 2. Of the thirty-three primary studies, twenty-eight targeted participants with cardiometabolic risk factors, primarily individuals with overweight or obesity. Five studies met eligibility criteria that targeted participants with cardiometabolic disease (type 2 diabetes mellitus and CVD)[46,83,104,147,161], and another five studies included participants with another morbidity, sarcopenia[69,121,149,172] and non-severe anxiety and depression[90] in four and one study, respectively. Two trials (entitled the *TXT2Bfit* and *40 something* trials) included participants who were both at cardiometabolic risk and who did not have cardiometabolic risk factors but were at risk of weight gain[49,138,139] or were perimenopausal women[108,177]. Sample sizes ranged from 28 to 11 827 participants and study durations ranged from 4 weeks to 8 years. Nutrition and physical activity counseling or coaching was provided by a dietitian/nutritionist only in fifteen studies[15,32,46,47,52,83,89,101,128,139,147,151,160,162,182], an exercise practitioner only in two studies[56,184] and both a dietitian/nutritionist and exercise practitioner in twenty-one studies[51,69,78,90,91,102,103,108,111,120,121,130,142,149,161,169,171,172,180]. The greatest density of studies examined participants with cardiometabolic risk factors and interventions delivered by a dietitian/nutritionist and exercise practitioner or a dietitian/nutritionist only, and reporting anthropometric, glucose homoeostasis, blood pressure, lipid profile, dietary intake and physical activity outcomes. The one included SR reported the outcome of weight change[32]. Exercise practitioners providing interventions were heterogeneous and included physiotherapists (*n* 4), exercise physiologists (*n* 7), physical trainer (*n* 1), physical activity 'specialist' or 'coach' (*n* 3), exercise or physical activity instructors (*n* 3) and health coaches (*n* 2) among others.

Question 2: Nutrition and physical activity mobile apps and/or wearable technology

A total of thirty-six articles[18,19,21,22,30,34,35,37,40,42–44,48,59,80,87,94,95,97,100,106,109,113,119,123,126,129,140,141,143–145,147,176,181,183] representing thirty studies were included for Q2, which examined the effects of nutrition and physical activity mobile apps and/or wearables. Studies included were SR (*n* 12), RCT (*n* 16) and non-RCT (*n* 2). The populations, study designs and reported outcomes are shown in Table 3. Ten studies included participants who were

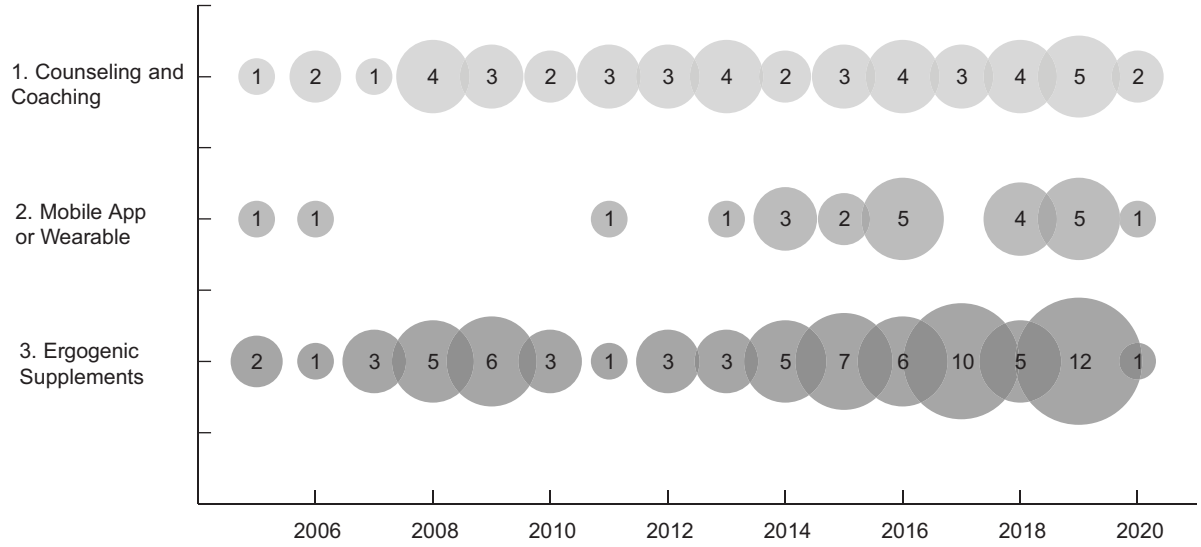

Fig. 2 Bubble chart of publication trends in primary research articles published from 2005 to 2020 according to the research question addressed

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Table 2 Primary studies examining the effect of nutrition and physical activity counseling/coaching according to the provider of intervention and outcomes reported (*n* 36 studies)

	Nutrition and exercise practitioner (*n* 21)			Nutrition practitioner only (*n* 14)			Exercise practitioner only (*n* 2)		
Outcomes reported	Cardiometabolic disease risk (*n* 15)*	Cardiometabolic disease (*n* 2)†	Other morbidity (*n* 4)	Cardiometabolic disease risk (*n* 11)*	Cardiometabolic disease (*n* 3)	Other morbidity (*n* 0)	Cardiometabolic Disease Risk (*n* 2)*	Cardiometabolic disease (*n* 0)	Other morbidity (*n* 0)
Mortality	0	0	0	0	0	0	0	0	0
Quality of life	1[111]	0	0	0	0	0	0	0	0
CVD	0	0	0	1[52]	0	0	0	0	0
Type 2 diabetes mellitus	1[78]	0	0	2[148,162]	0	0	0	0	0
Metabolic syndrome	0	0	0	1[151]	0	0	0	0	0
Nutritional status	1[103]	0	0	0	0	0	1[184]	0	0
Anxiety/ depression	1[111]	0	0	0	0	0	0	0	0
Bone health‡	0	0	2[69,90]	0	0	0	0	0	0
Anthropometrics	13[51,78,91,102,103,109,111, 120,130,169,171,177,180]	1[104]	3[90,121,172]	9[47,49,89,101,139, 151,160,162,182]	3[4,147,683]	0	2[56,184]	0	0
Body composition	5[51,91,169,177,180]	0	3[69,121,172]	3[148,158]	0	0	0	0	0
Glucose homoeostasis	7[51,78,109,120,130,177,180]	0	1[69]	4[47,89,151,162]	1[46]	0	1[184]	0	0
Blood pressure	9[51,78,102,103,109,120,130,177,180]	0	0	5[15,47,89,101,151]	1[46]	0	2[56,184]	0	0
Lipid profile	9[51,78,102,103,109,120,130,177,180]	0	0	6[47,89,101,151,160,182]	2[46,83]	0	1[184]	0	0
Inflammatory marker	0	0	1[69]	2[89,150]	0	0	0	0	0
Dietary intake	11[51,78,102,103,108,109,130,142,169,171,180]	0	3[90,121,172]	6[89,101,128,139,151,160]	1[46]	0	1[184]	0	0
Physical activity	12[51,78,102,103,108,109,111,120,142,169,171,180]	0	2[69,172]	7[49,89,101,128,139,151,160]	1[46]	0	1[184]	0	0

Red colour = >5 studies, light orange colour = 1–5 studies, light yellow colour = no available studies.
*Includes cardiovascular risk, type 2 diabetes mellitus risk, overweight and obesity and metabolic syndrome.
†Simpson *et al.*[191] reported frailty index, which is not reported in the table.
‡Includes osteopenia, osteoporosis, osteoarthritic and bone mineral density/content.

Table 3 Heat map of controlled trials examining the effect of mobile apps and/or wearable devices for nutrition and physical activity according to the target populations and reported outcomes (*n* 30 studies)

	Healthy (*n* 10)		Cardiometabolic risk (*n* 20)*		Cardiometabolic disease (*n* 6)	
Outcome reported	Controlled trials (*n* 7)	Systematic reviews (*n* 3)	Controlled trials (*n* 14)	Systematic reviews (*n* 7)	Controlled trials (*n* 2)	Systematic reviews (*n* 4)
Mortality	0	0	0	0	0	1[43]
Quality of life	0	0	0	0	1[176]	2[30,43]
CVD/events	0	0	0	0	0	0
Type 2 diabetes mellitus	0	0	0	0	0	0
Metabolic syndrome	0	0	0	0	0	0
Nutritional status	0	0	0	0	0	0
Anxiety/depression	1[181]	0	1[113]	0	1[176]	0
Bone health	0	0	0	0	0	0
Anthropometrics	4[80,87,95,123]	2[37,40]	12[48,59,95,100,106,109,113,126,129,140,141,183]	6[18,19,21,22,35,40]	2[147,176]	2[43,44]
Body composition	2[95,123]	0	4[48,59,113,126]	2[19,35]	0	0
Glucose homoeostasis	1[97]	1[37]	4[48,97,109,126]	1[35]	1[176]	3[42–44]
Blood pressure	1[97]	1[37]	5[48,97,109,126,129]	2[19,35]	0	1[43]
Lipid profile	1[97]	1[37]	4[48,97,100,109]	1[35]	0	1[42]
Inflammatory markers	1[97]	0	1[97]	0	0	0
Dietary intake	4[87,94,123,181]	2[34,37]	8[48,94,106,109,113,140,141,183]	4[19,21,34,35]	0	1[30]
Physical activity	4[87,94,123,181]	3[34,37,40]	9[59,94,100,106,109,113,126,140,141]	7[18,19,21,22,34,35,40]	0	2[30,43]
Cost effectiveness	0	0	0	0	0	0

Red colour = >5 studies, light red colour = 1–5 studies, blue colour = no available studies.
*Includes CVD risk, type 2 diabetes mellitus risk, overweight and obesity and metabolic syndrome.

healthy[22,34,37,40,80,87,94,97,123,181] and twenty-one studies included participants with cardiometabolic risk factors[18,19,21,22,34,35,40,48,59,94,95,97,100,106,109,113,126,129,140,141,183]. Only six studies meeting eligibility criteria included participants with cardiometabolic diseases (type 2 diabetes mellitus and CVD)[30,42–44,147,176]. Five studies included both participants who were both healthy and those who had cardiometabolic risk factors[22,34,40,94,97]. Sample sizes ranged from 34 to 1007 participants and study durations ranged from 8 to 32 weeks. There were no patient-centred health outcomes reported for studies with participants who were healthy or at cardiometabolic risk. The greatest density of primary studies and SR examined individuals with cardiometabolic risk factors and reported anthropometric, dietary intake and physical activity outcomes. Six SR addressed the efficacy of mobile apps and wearables for nutrition and physical activity and were published from 2019 until the search date of 4 May 2020[18,21,34,35,40,44].

Question 3: Nutritional ergogenic aids

A total of eighty-seven articles, including seventeen SR[16,17,20,23–29,31,33,36,38,39,41,45] and seventy placebo-controlled RCT[50,53–55,57,58,60–68,70–73,75,77,79,81,82,84–86,88,92,93,96,98,99,105,107,110,112,114–118,122,124,125,127,131,132,134–137,146,152,153,155–157,159,163–168,170,173,175,178,179], examined the effect of nutritional ergogenic aids on physical activity, anthropometric and body composition outcomes. Sample sizes ranged from 10 to 118 participants and study durations ranged from 1 d to 1 year. Nearly all included articles focused on one dietary supplement of interest (branched chain amino acids, caffeine, carbohydrate replacement, collagen, creatine, exogenous ketones, multivitamins and *n*-3 fatty acids), with the exception of one RCT that assessed both creatine and carbohydrate supplementation[118] and one SR that assessed both creatine and the branched chain amino acid leucine[17]. The most frequently examined ergogenic aid was creatine (*n* 6 SR[17,20,23,28,29,39] and 22 RCT[55,57,60–67,72,75,79,86,88,98,105,117,118,164,165,179]), followed by caffeine (*n* 5 SR[25–27,36,38] and 20 RCT[54,58,68,70,81,84,96,122,124,131,134,136,152,153,155,157,166–168,175]). There were no SR available for carbohydrate replacement (*n* 4 RCT[50,53,85,118]) or collagen (*n* 2 RCT[116,178]) in non- or recreational athletes. There were four SR[17,24,33,45] and six RCT[92,93,132,146,159,173] that focused on branched chain amino acids (primarily leucine); one SR[41] and two RCT[114,137] examined the effect of exogenous ketones; and two SR[16,31] and fifteen RCT[71,73,77,82,99,107,110,112,115,125,127,135,156,163,170] examined the effect of *n*-3 fatty acid supplementation. There were no placebo-controlled RCT or SR identified that evaluated the effect of multivitamins in the population of interest. Table 4 displays a heat map of the distribution of outcomes assessed in RCT and SR for each ergogenic aid of interest. Of the seventy included RCT, only two did not assess exercise/performance outcomes; one examined creatine[86] and that the other on *n*-3 fatty acids[107]. None of the included RCT measured physical activity outcomes using metabolic equivalents of task and only two of the SRs assessed metabolic equivalents of task as an outcome measure of interest[31,33]. For the nutritional ergogenic aids caffeine, creatine and *n*-3 fatty acid supplements, SR published in 2019 and 2020 were available (Fig. 3).

Discussion

This scoping review included 170 primary and secondary research articles that examined the effect of nutrition and physical activity interventions in individuals who were non-athletes or recreational athletes and who were healthy or had cardiometabolic risk. While primary research has been consistently available on the effect of individual-level nutrition and physical activity counseling or coaching from a dietitian or exercise practitioner, there has been little synthesis of these data in the 5 years of SR (2015–2020) examined. SR published prior to 2015 may be valuable for practice[185], but practitioners should be mindful that new evidence may shift conclusions. Additionally, newer SR may be more relevant to current circumstances (e.g., need for remote coaching/counseling during the COVID-19 pandemic). Mobile applications designed to improve nutrition and physical activity had been addressed in several primary studies over the past 5 years; these studies have been well-represented in SR. Regarding nutritional ergogenic aids of interest, recent SR were available for the supplements with relatively high publication activity (caffeine, creatine and *n*-3 fatty acids), particularly for the outcome of exercise performance. However, other commonly used ergogenic aids have relatively few SR available to guide practice.

Question 1: Individual-level nutrition and physical activity counseling or coaching provided by a dietitian/nutritionist or exercise practitioner

Prior education, experience, methodologies and assessment techniques can differ significantly among practitioners delivering nutrition and physical activity interventions. Studies in this scoping review included a range of practitioners providing nutrition and exercise counseling or coaching, particularly among exercise practitioners. In addition, state and federal regulations for scope of practice vary, potentially allowing less-than-qualified practitioners to provide nutrition and/or physical activity guidance. While decreasing standards may increase accessibility, there is also risk of lower quality care and, therefore, lower intervention efficacy when care is provided by non-qualified practitioners. Examining how provider qualifications impact outcomes may inform scope of practice for both dietitian/nutritionists and exercise practitioners working with different sub-groups of the 'general' population. For example, those with cardiometabolic disease or risk factors for cardiometabolic disease may require medical nutrition therapy provided by a Registered Dietitian, while direct coaching from an exercise practitioner may be required for individuals who are

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Table 4 Heat map of placebo-controlled randomised controlled trials and systematic reviews examining the effect of ergogenic aids according to the supplement and reported outcomes (*n* 87 studies)

Nutritional ergogenic supplement	Study design	Exercise/performance outcome	Anthropometric outcome	Body composition outcome
Branched chain amino acids (*n* 10)	RCT (*n* 6)	6[92,93,132,146,159,173]	2[93,132]	3[93,132,173]
	Systematic reviews (*n* 4)	3[17,24,33]	0	3[17,33,45]
Caffeine (*n* 25)	RCT (*n* 20)	20[54,58,68,70,81,84,96,122,124,131,134,136,152,153,155,157,166–168,175]	0	0
	Systematic reviews (*n* 5)	5[25–27,36,38]	0	0
Carbohydrate replacement (*n* 4)	RCT (*n* 4)	4[50,53,85,118]	1[118]	0
	Systematic reviews (*n* 0)	0	0	0
Collagen (*n* 2)	RCT (*n* 2)	2[116,178]	2[116,178]	2[116,178]
	Systematic reviews (*n* 0)	0	0	0
Creatine (*n* 28)	RCT (*n* 22)	21[55,57,60–67,72,75,79,88,98,105,117,118,164,165,179]	10[60,61,72,86,88,98,105,118,164,179]	13[55,60–63,67,72,75,86,88,117,164,165]
	Systematic reviews (*n* 6)	4[17,28,29,39]	0	4[17,20,23,39]
Exogenous ketones (*n* 3)	RCT (*n* 2)	2[114,137]	0	0
	Systematic reviews (*n* 1)	1[41]	0	0
Multivitamins (*n* 0)	RCT (*n* 0)	0	0	0
	Systematic reviews (*n* 0)	0	0	0
n-3 (*n* 17)	RCT (*n* 15)	14[71,73,77,82,99,110,112,115,125,127,135,156,163,170]	5[82,107,115,127,163]	5[73,77,127,163,192]
	Systematic reviews (*n* 2)	2[16,31]	1[31]	1[16]

Red colour = >5 studies identified; orange colour = 1–5 studies identified; light yellow colour = no studies identified.

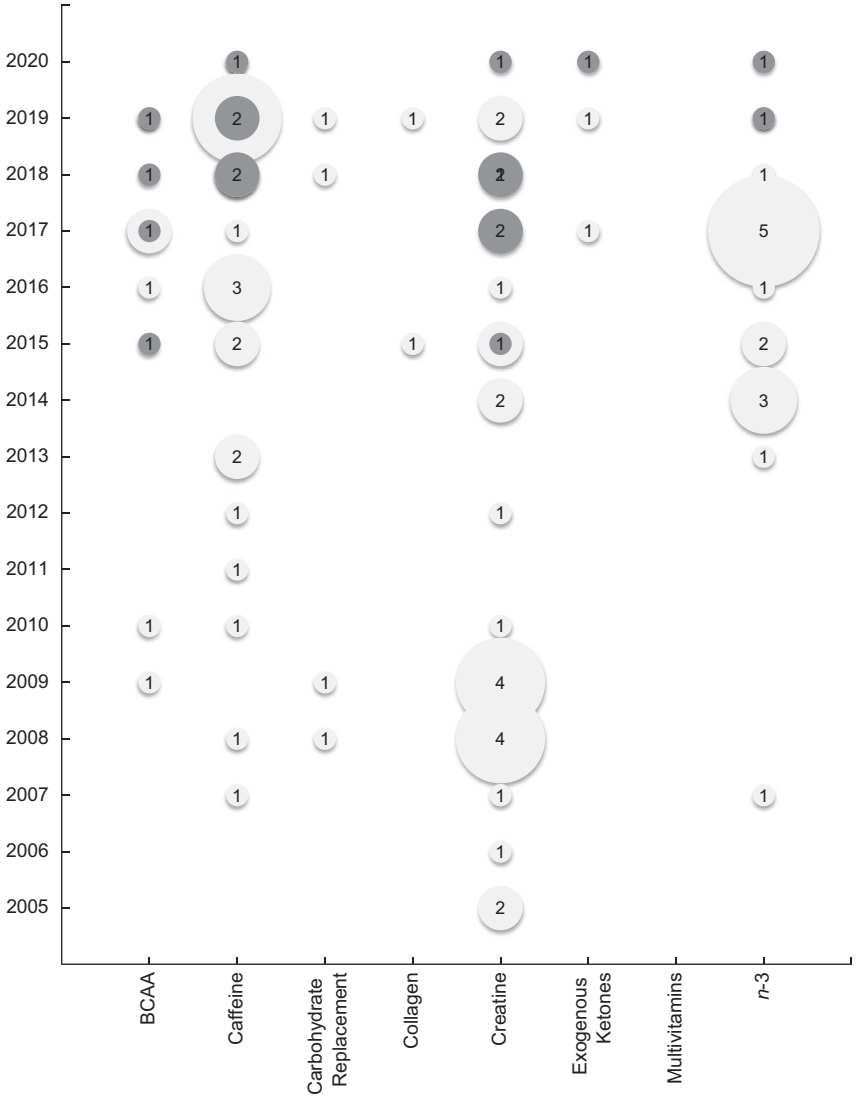

Fig. 3 Bubble chart of placebo-controlled randomised controlled trials and systematic reviews published by year and by ergogenic aid. The bubble size is proportional to the number of studies published in the year for each ergogenic aid. ○, RCT; ●, SR

sedentary and/or have little exercise history. There were no studies included that investigated the effect on an intervention in individuals that had no cardiometabolic risk factors or disease. Most available primary studies investigated individuals with cardiometabolic risk, such as those with overweight or obesity, and investigated intermediate outcomes such as anthropometric measures, blood pressure, lab values and behavioural outcomes, which would indicate the prevention of progression towards cardiometabolic disease. A SR on the effects of nutrition and physical activity interventions in individuals with no risk factors may yield few results. However, signs and symptoms of cardiometabolic risk, such as incidence of overweight and pre-diabetic levels of fasting blood glucose, may overlap. Thus, in SR, it may be beneficial to group individuals with cardiometabolic risk factors, but without diagnosed disease.

The United States Preventative Task Force recently conducted a SR on the effect of behaviour counseling for nutrition and physical activity for individuals with cardiovascular risk on CVD outcomes[186]. The current working version describes a beneficial effect on cardiovascular events, adiposity-related outcomes and many other health outcomes[187]. The current scoping review focused on interventions delivered by nutrition and/or exercise practitioners specifically and included a broader range of participants. SR examining differences in outcomes according to the practitioner delivering the intervention can inform health care providers of the most effective methods to improve dietary intake and physical activity behaviours.

Question 2: Nutrition and physical activity mobile apps and wearable technology

Most studies examining the effectiveness of mobile apps in improving cardiometabolic risk factors have reported outcomes relating to energy intake, storage and output

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(dietary intake, anthropometrics and physical activity, respectively, Table 3). Fewer studies have assessed the influence of apps on treating those with cardiometabolic conditions, such as type 2 diabetes mellitus and CVD. This discrepancy may be intentional to curtail liability from self-diagnosis or self-treatment based on data or guidance from the app itself and in the absence of a qualified nutrition or exercise practitioner. However, several SR targeting individuals who are healthy or who have cardiometabolic risk factors are available to guide practitioners on the efficacy of utilising mobile apps with clients[18,19,21,22,30,34,35,37,40,42–44]. Studies investigating individuals without cardiometabolic disease may offer valuable insights in broad-scale interventions implemented prior to individuals experiencing adverse symptoms of cardiometabolic risk and disease. Like the question investigating nutrition and physical activity counseling or coaching (Question 1), the highest density of evidence available examined individuals with cardiometabolic risk factors. These interventions most frequently reported outcomes that would indicate improved behaviours and intermediate outcomes that may indicate the prevention of cardiometabolic disease.

Use of and technology related to smartphone applications and forms of telehealth will likely continue to advance[188,189], particularly in light of the need for remote interventions due to the COVID-19 pandemic. Thus, the number of available studies in this domain may require further synthesis including examination of effective app components, differences between apps that simply track behaviour or biomarker data compared with those which provide recommendations and differences in apps developed directly by medical providers (hospitals, insurance providers) *v.* third-party companies.

Question 3: Nutritional ergogenic aids

Participants were healthy individuals without cardiometabolic risk factors in all except two studies investigating the effect of ergogenic aids[107,178]. The greatest availability of research on nutritional ergogenic aids was for creatine, caffeine and *n*-3 fatty acids. Individuals typically use creatine to increase strength and power and may be of particular relevance to older individuals seeking to maintain or build strength, function and potentially cognition. While primary research on creatine as an ergogenic aid has waned in recent years, several SR have been published from 2017 to 2020, including in the ageing population[17,20,23,28,29,39], and these can be used as resources to guide practitioner advice on creatine supplementation. There is more availability of recent studies examining caffeine[26,27,36,38,190] and *n*-3 fatty acids[16,31] as ergogenic aids, but these have also been investigated in recent SR as recently as the year this search was conducted. When interpreting this evidence, practitioners should consider if the outcomes of interest align with the performance goals of the client including increased time spent exercising, enhanced endurance, strength or decreased pain. While little of the included research targeted individuals with cardiometabolic risk factors, the use of nutritional ergogenic aids may be common in these individuals to improve exercise endurance and capacity. Thus, when working with individuals with cardiometabolic risk factors, practitioners should consider how to appropriately interpret and modify conclusions and recommendations for clients.

Strengths and limitations

This scoping review had rigorous methods and comprehensively described interventions including both nutrition and physical activity. Another strength of this scoping review was inclusion of populations with a range of cardiometabolic risk that may be representative of the population in economically developed countries, such as the USA. This included individuals who were healthy, overweight or obese, or with cardiometabolic disease. However, the authors did set the parameter that studies would be excluded if they included participants with a BMI of ≥40 kg/m^2, with the intention that this relatively arbitrary line may be a proxy for the point at which medical interventions may be necessary beyond 'standard' diet and exercise. This is evident in the few studies included that focused on individuals with cardiometabolic disease; most of which included some participants with BMI ≥ 40 kg/m^2 and were thus excluded. Future studies may elucidate more relevant measures to stratify individuals who have therapeutic *v.* 'general' needs. Due to the wide breadth of nutrition and physical activity interventions, it was necessary to categorise populations, interventions and outcomes very broadly, thus masking heterogeneity between these studies. Future SR should consider how efficacy of interventions vary according to an individual's cardiometabolic risk factors, diet and physical activity history and ability, and methods of data collection for dietary intake and physical activity outcomes. Improving understanding of how early interventions may prevent onset or progression of cardiometabolic risk factors prior to disease onset would allow for a development of a framework describing how interventions can be effectively individualised to specific clients but implemented on a broad scale. Increased attention to and rigor of data collection methods, including for dietary and physical activity behaviours, will improve quality of and certainty in evidence to inform practice.

Additional limitations of this scoping review were inclusion of evidence published in the English language only, which may have resulted in missing relevant studies published in other languages, and not all titles/abstracts were screened by two reviewers due to resource constraints and the wide breadth of evidence identified on the topic of interest. These limitations may have resulted in missing relevant articles published on the topics of interest. Also, while this scoping review aimed to identify

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primary studies published in the 15 years prior to the search and SR published in the 5 years prior to the search, as mentioned, earlier evidence may still be relevant and helpful to practitioners.

Conclusion

Interventions to improve or maintain both nutrition and physical activity can provide clients with the knowledge, skills and tools needed to prevent and treat cardiometabolic risk factors and disease. Several recent SR on the efficacy of nutrition and physical activity mobile apps and nutritional ergogenic aids can serve as evidence-based resources for health practitioners. Though consistent literature has been published examining the effect of providing nutrition and exercise counseling by practitioners in these fields, this evidence has not been synthesised. SR of these targeted interventions may inform scope of practice for dietitians and exercise practitioners working with individuals who are healthy or who have cardiometabolic risk factors. More research is needed examining the long-term effects of nutrition and physical activity interventions on patient-centred health outcomes.

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Supplementary material

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