




Impact of risk factor control interventions for smoking cessation and promotion of healthy lifestyles in patients with periodontitis: A systematic review

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Abstract

Aim: The aim of this systematic review was to identify the most recent widely accepted guidelines for risk factor control interventions and to assess their impact in patients with periodontitis.

Materials and methods: The electronic search strategy included a first systematic search to identify guidelines for interventions for smoking cessation, diabetes control, physical exercise (activity), change of diet, carbohydrate (dietary sugar) reduction and weight loss in the general population and a second systematic search to identify the studies evaluating these interventions in periodontitis patients.

Results: A total of 13 guidelines and 25 studies were selected. Most guidelines included recommendations for all healthcare providers to provide interventions and follow-up counselling with the risk factors considered in the present review. In patients with periodontitis, interventions for smoking cessation and diabetes control were shown to improve periodontal health while the impact of dietary interventions and the promotion of other healthy lifestyles were moderate or limited.

Conclusions: While aiming to improve treatment outcomes and the maintenance of periodontal health, current evidence suggests that interventions for smoking cessation and diabetes control are effective, thus emphasizing the need of behavioural support in periodontal care.

KEYWORDS

change of diet, periodontitis, risk factors, smoking cessation

1 | INTRODUCTION

Common aetiological causes and risk factors associated with the progression of periodontitis have been identified through extensive epidemiologic and clinical research. Next to providing instructions for the improvement of self-performed oral hygiene, individual risk factors may be controlled through interventions to improve periodontal treatment outcomes and the maintenance of periodontal health (Newton & Asimakopoulou, 2015; Ramseier & Suvan, 2010).

The importance of the patients' motivation and their adherence to the behaviour necessary for the maintenance of periodontal health has been widely acknowledged (Tonetti et al., 2015). In general health care, as addressed by the World Health Organization (WHO), the management of noncommunicable diseases as a growing global burden requires all health care providers to tackle the issues of high blood pressure, high concentrations of cholesterol in the blood, inadequate intake of fruit and vegetables, overweight or obesity, physical activity and tobacco use (WHO, 2004). Similarly,

national public health organizations and dental associations request their oral health professionals to engage in the management of chronic diseases through interventions and behavioural support with all their patients. However, the implementation of health behaviour change counselling into periodontal practice remains challenging. Periodontitis patients need continuous professional care including behavioural support to reduce the harmful impact of both aetiological causes and risk factors. Current evidence from clinical studies reveal that smoking cessation (Leite et al., 2018), diabetes control (Botero, Rodriguez, & Agudelo-Suarez, 2016; Kapellas et al., 2017), increase in physical activity (Ferreira et al., 2019), dietary adjustments (Skoczek-Rubinska, Bajerska, & Menclawicz, 2018; Van der Velden, Kuzmanova, & Chapple, 2011) and weight loss (Weyant et al., 2004) improve periodontal health and the patients' quality of life. Therefore, periodontal care providers have a key role to play in supporting their patients' health behaviour and thus face the challenge to adopt interventions for the promotion of health behaviour change specifically through interventions for smoking cessation, diabetes control, increase in physical exercise (activity), change of diet, carbohydrate (dietary sugar) reduction or weight loss.

According to current reports, oral health professionals are increasingly engaged in counselling activities with their periodontitis patients (Kopp, Ramseier, Ratka-Kruger, & Woelber, 2017). However, consensus about the impact of these interventions is limited. Therefore, the aim of the present systematic review was to identify the most recent widely accepted guidelines for interventions for smoking cessation, diabetes control, physical exercise, change of diet, carbohydrate (dietary sugar) reduction and weight loss in the general population and to further evaluate the impact of these interventions in patients with periodontitis.

2 | MATERIALS AND METHODS

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) were used for reporting this systematic review (Liberati et al., 2009; Moher, Liberati, Tetzlaff, & Altman, 2010). The study protocol has been approved by all co-authors and by the supervising committee of the 16th European Workshop of the European Federation of Periodontology (EFP). The study has been registered at the National Institute for Health Research (NHR) under the PROSPERO ID 142232.

2.1 | Systematic search strategy

For the purpose of this systematic review, the electronic search strategy consisted of two stages: stage I) a systematic search for the identification of the most recent widely accepted guidelines for interventions for smoking cessation, diabetes control, physical exercise (activity), change of diet, carbohydrate (dietary sugar) reduction and weight loss in the general population; and stage II) a subsequent

Clinical Relevance

Scientific rationale for the study: Periodontitis patients may benefit from additional risk factor control interventions to improve periodontal treatment outcomes and the maintenance of periodontal stability.

Principal findings: Established guidelines for risk factor control interventions are available for smoking cessation, diabetes control, physical exercise (activity), change of diet, carbohydrate (dietary sugar) reduction and weight loss. In periodontitis patients, interventions for smoking cessation and diabetes control are effective while current evidence for the promotion of other healthy lifestyles is limited.

Practical implications: In patients with periodontitis, smoking cessation and diabetes control can be effective and thus improve their oral health.

systematic search to identify the studies evaluating these interventions in patients with periodontitis.

2.2 | Focused question

For the identification of the clinical studies, the following focused question was adapted using the PICO criteria (Miller & Forrest, 2001): "What is the efficacy of health behaviour change interventions for smoking cessation, diabetes control, physical exercise (activity), change of diet, carbohydrate (dietary sugar) reduction and weight loss provided in patients with periodontitis?". The subsequent phrases for a systematic search strategy using population (P), intervention (I), comparison (C) and outcomes (O) (PICO) were used:

Population: adults with periodontitis

Intervention or exposure: health behaviour change intervention for smoking cessation, diabetes control, physical exercise (activity), change of diet, carbohydrate (dietary sugar) reduction and weight loss.

Comparison: control group of patients without an intervention, with a different intervention (e.g. a different dietary intervention), or a different outcome following an intervention (e.g. unsuccessful smoking cessation).

Outcomes: changes in behaviour, improvement of periodontal health as determined by changes of periodontal outcome variables.

2.3 | Scope

Randomized clinical trials (RCTs) and controlled clinical trials (CCTs) were eligible for inclusion if they were conducted in human subjects with the intervention being the risk factor control (health behaviour change) intervention provided in patients with periodontitis. Animal

studies, abstracts, letter to editors, narrative reviews and case reports were excluded. Studies not reporting on the nature of the intervention were excluded.

2.4 | Search and screening

The electronic search strategy framework was developed individually for both stages of the search and tested to confirm its suitability to the focus of the present systematic review. A combination of MeSH terms and free text words were used by means of the following key words: clinical practice guideline, intervention, periodontitis, smoking cessation, diabetes control, physical exercise (activity), change of diet, carbohydrate (dietary sugar) reduction and weight loss. Due to ethical restrictions, for example with trials for smoking cessation interventions, both RCTs and CCTs were considered. The electronic search included the search of electronic databases up to May 2019 using a basic search strategy set a priori and customized as appropriate for each database (PubMed Medline and EMBASE Ovid).

Due to the limited time available to accomplish the review, only publications written in the English language were considered. Hand searching was comprised of checking bibliographic references of review articles and potentially suitable full-text articles. In addition, online hand searching of publications from the preceding 5 years of key periodontal journals was performed (Journal of Clinical Periodontology, Journal of Periodontology).

The results of all searches were first combined in one EndNote database and duplicates were removed. All titles and abstracts (when available) of all records identified through the search were scanned by three reviewers independently (JK, JPW and CAR). Disagreements at the title, abstract or full-text screening level were discussed and resolved by consensus among the three reviewers. Narrative or irrelevant reviews were excluded, and possibly relevant full-text review articles were obtained. The full-text articles were further screened to confirm their eligibility for inclusion.

2.5 | Methodological quality assessment

The quality assessments of the included clinical trials were based on their study design. With respect to RCTs and CCTs, quality assessment was performed by means of the Cochrane Collaboration's tool for assessing risk of bias (www.cochrane-handbook.org).

2.6 | Data extraction

Data were extracted from full-text articles directly into electronically generated evidence table templates. Data abstraction was performed in collaboration (JK, JPW and CAR) on all included studies. Completed evidence tables were further rechecked to validate accuracy of the data abstraction.

3 | RESULTS

3.1 | Guideline selection

Based on the search strategy for stage I (guideline selection), a total of 443 titles and abstracts were identified. Following the elimination of duplicates, 371 titles and abstracts were screened resulting in 60 full-text items to be assessed for eligibility (Figures A through F in Figure S1). At the first eligibility assessment, 47 items were excluded resulting in 13 guidelines eligible for inclusion (Table 1). These guidelines specifically aimed to address risk factor control interventions provided by healthcare providers in the general population for smoking cessation (Fiore et al., 2008), diabetes control (Powers et al., 2016; VA/DoD, 2017; WHO, 2006), physical exercise (activity) (Azar, 2018; Rütten & Pfeifer, 2016; WHO, 2010), change of diet (FANTA, 2016; WHO, 2004), carbohydrate (dietary sugar) reduction (WHO, 2015) and weight loss (Fitzpatrick et al., 2016; NIH, 1998; Yumuk et al., 2015).

3.2 | Study selection

Following the search strategy for stage II (study selection), a total of 2030 titles and abstracts were identified. After eliminating duplicates, a total of 1897 titles and abstracts were screened resulting in 93 full-text articles to be assessed for eligibility (Figures G through L in Figure S1). At the first eligibility assessment, 65 items were excluded resulting in 25 studies eligible for inclusion (Tables 2–6). These studies evaluated the following six risk factor control interventions in patients with periodontitis: smoking cessation (Bassetti et al., 2017; Binnie, McHugh, Jenkins, Borland, & Macpherson, 2007; Kropff et al., 2016; Preshaw et al., 2005; Rosa et al., 2014; Schoonheim-Klein, Gresnigt, & van der Velden, 2013), diabetes control (Holmer et al., 2018; Nishihara et al., 2017; Saengtibovorn & Taneepanichskul, 2015), physical exercise (activity) (Omori et al., 2018; Sudhanshu, Sharma, Vadiraja, Rana, & Singhal, 2017), change of diet (Fridell et al., 2018; Holmer et al., 2018; Jenzsch, Eick, Rassoul, Purschwitz, & Jentsch, 2009; Kondo et al., 2014; Omori et al., 2018; Woelber et al., 2016; Zare Javid, Seal, Heasman, & Moynihan, 2014), carbohydrate (dietary sugar) reduction (Kondo et al., 2014; Woelber et al., 2016) and weight loss (Kondo et al., 2014; Martinez-Herrera et al., 2018; Omori et al., 2018; Sales-Peres, Sales-Peres, Ceneviva, & Bernabe, 2017; Vivekananda & Faizuddin, 2019).

Two studies qualified for the descriptive analysis of two risk factor control interventions (Holmer et al., 2018; Woelber et al., 2016) while two other studies were found eligible to qualify for the descriptive analysis of three risk factor control interventions (Kondo et al., 2014; Omori et al., 2018).

3.3 | Excluded studies

Excluded studies and the reasons for exclusion are listed in Table A in Table S1. The majority of the studies excluded from the present

TABLE 1 Clinical practice guidelines for smoking cessation, diabetes control, physical exercise, change of diet, carbohydrate (sugar) reduction and weight loss (in chronological order of their publication)

Risk factor intervention	Title	Organization	Authors and year	Healthcare providers	Intervention methods	Meta-analysis included	Additional Remarks
Smoking cessation	Treating Tobacco Use and Dependence: 2008 Update	U.S. Department of Health and Human Services, U.S. Public Health Service	Fiore et al. (2008)	All healthcare providers	The 5 A's (ask, assess, advise, assist, arrange), behavioural support interventions (including brief interventions) and pharmacotherapy	Yes	Update of the originally published clinical practice guidelines in 2000(Fiore, 2000)
Diabetes control	Guidelines for the prevention, management and care of diabetes mellitus	World Health Organization (WHO)	(WHO, 2006)	Physicians, clinical dieticians, nurses and policymakers at ministries of health	Counselling with a multidisciplinary diabetes team (including diabetes educator, dietician or psychologist) to improve diet and physical exercise and anti-diabetic medication	No	-
	Diabetes Self-management Education and Support in Type 2 Diabetes: A Joint Position Statement of the American Diabetes Association, the American Association of Diabetes Educators and the Academy of Nutrition and Dietetics	American Diabetes Association, the American Association of Diabetes Educators, and the Academy of Nutrition and Dietetics	(Powers et al., 2016)	Physicians, clinical dieticians, psychologists, nurses	Diabetes education and support for the successful diabetes self-management	No	-
	U.S. Department of Veterans Affairs/ U.S. Department of Defence Clinical Practice Guideline: Management of Type 2 Diabetes Mellitus	U.S. Department of Veterans Affairs (VA) and the U.S. Department of Defence (DoD)	VA/DoD (2017)	All healthcare providers	Ongoing individualized diabetes self-management education (counselling) via various modalities	Yes	Synopsis published by Conlin et. al. (2017) (Conlin, Colburn, Aron, Pries, Tschanz et al., 2017)
Physical exercise (activity)	Global Recommendations on Physical Activity for Health	World Health Organization (WHO)	(WHO, 2010)	All healthcare providers	Physical activity promotions	No	-
	National Recommendations for Physical Activity and Physical Activity Promotion	German Federal Ministry of Health	(Rütten & Pfeifer, 2016)	All healthcare providers	Physical activity promotion for children and adolescents, adults, older adults, adults with a chronic disease and the general population	Yes (level of evidence)	-
	Physical Activity Guidelines for Americans, 2nd edition	U.S. Department of Health and Human Services	(Azar, 2018)	All healthcare providers	Physical activity promotion for various age groups	No	-

(Continues)

TABLE 1 (Continued)

Risk factor intervention	Title	Organization	Authors and year	Healthcare providers	Intervention methods	Meta-analysis included	Additional Remarks
Change of diet	World Health Organization (WHO) Global Strategy on Diet, Physical Activity and Health	World Health Organization (WHO)	(WHO, 2004)	All healthcare providers	Promotion of healthy diets	No	-
	Nutrition Assessment, Counseling, and Support (NACS): A User's Guide—Module 3: Nutrition Education and Counseling	Food and Nutrition Technical Assistance III Project (FANTA)	(FANTA, 2016)	All healthcare providers	The GALIDRAA approach (greet, ask, listen, identify, discuss, recommend) including nutrition education and counselling	No	-
Carbohydrate (dietary sugar) reduction	Sugars intake for adults and children	World Health Organization (WHO)	(WHO, 2015)	All healthcare providers	Reduction in dietary sugars through dietary counselling	Yes	-
Weight loss	Clinical Guidelines on the identification, evaluation, and treatment of overweight and obesity in adults	U.S. National Institute of Health (NIH): National Heart, Lung, and Blood Institute in cooperation with The National Institute of Diabetes and Digestive and Kidney Diseases	NIH, (1998)	All healthcare providers	Behavioural strategies following a treatment algorithm	Yes	-
	European Guidelines for Obesity Management in Adults	N/A	Yumuk et al. (2015)	All healthcare providers	Behavioural strategies following a care pathway	No	-
	An Evidence-based Guide for Obesity Treatment in Primary Care	N/A	Fitzpatrick et al. (2016)	All healthcare providers	5A's counselling framework (assess, advise, agree, assist and arrange) and behavioural strategies following a treatment algorithm	Yes	-

TABLE 2 Included studies on smoking cessation interventions in patients with periodontitis (in chronological order of their publication)

Study	Type of study and duration	Study settings and industrial funding	Study sample	No. of subjects	Type(s) of intervention	Primary outcome(s)	Secondary outcome(s)	Risk of bias and remarks
(Preshaw et al., 2005)	Prospective study 12 months	University -	Smokers with periodontitis	49	Non-surgical periodontal therapy and SPT plus smoking cessation counselling according to individual needs	20% (n = 10) quitters, 20% (n = 10) continued smoking and 12% (n = 6) were oscillators.	After 1, year quitters were significantly more likely to demonstrate probing depth reductions \geq 2mm than non-quitters and oscillators	Moderate -
(Binnie et al., 2007)	Prospective study 12 months	University -	Dental hygiene students and their patients (smokers) with periodontitis	59 intervention 57 control	5 A's (ask, advise, assess, assist and arrange including follow-up	At 3, 6 and 12 months, 15%, 7% and 4% of the intervention group had quit smoking compared to 9%, 5% and 4% control quitters, respectively.	A statistically higher percentage of intervention participants made quit attempts compared with the control group.	Moderate -
(Rosa et al., 2014)	Prospective study 24 months	University -	Smokers with periodontitis	116	Non-surgical periodontal treatment and SPT plus concurrent smoking cessation treatment of four once-weekly sessions including CBT and MI	61 smokers remained in the study after 2 years. Of these, 18 (30%) quit smoking, 32 (52%) continued smoking and 11 (18%) oscillated.	After 1 year, only quitters presented significant clinical attachment gain and significant higher reduction in PD.	moderate Follow-up of (Rosa, Corraini, de Carvalho, Inoue, Gomes et al., 2011)
(Schoonheim-Klein et al., 2013)	Prospective study 12 months	University -	Dental students and their patients (smokers) with periodontitis	54 test (smoking cessation counselling) 22 control	MI training for dental students over 2 years. Students provided smoking cessation with MI to their patients.	1 year following intervention, 20% of patients quit smoking.	1 year following intervention, 39% of students quit smoking.	Moderate -
(Kropff et al., 2016)	Prospective study 12 months	University -	Smokers with periodontitis during SPT	469 59 (12.6%) of these were smokers; 30 (50.6%) of these patients participated in the smoking cessation programme	Cognitive behavioural group therapy of 10 once-weekly sessions for smoking cessation	6 patients were smoke-free after 10 weeks and five after 18 weeks (33.3%); two patients had reduced their cigarette consumption by half.	Participants in group therapy smoked more cigarettes/day, were higher motivated to quit smoking and subjectively assessed their health as being worse than non-participants.	Moderate -
(Bassetti et al., 2017)	Prospective study 6 months	University -	Smokers with periodontitis	50 patients during APT (test), 26 of these were smokers (31.6%) 50 smokers during SPT (control)	Non-surgical periodontal treatment both with tobacco use brief interventions	No change in the patients' awareness of smoking as a risk factor for periodontitis.	No increase in quit rates	Moderate -

Abbreviations: APT, active periodontal treatment; CBT, cognitive behavioural therapy; MI, motivational interviewing; PD, probing depth; SPT, supportive periodontal therapy.

analysis were lacking the use of an intervention in their study design, for example the investigations of Baumgartner et al. (2009) studying the impact of the stone age diet in gingival conditions or Merchant, Pitiphat, Rimm, and Joshipura (2003) evaluating the influence of increased physical activity on periodontal health (Baumgartner et al., 2009; Merchant et al., 2003).

3.4 | Quality assessment

All included studies were deemed to have low or moderate risk of bias based upon analysis according to the Cochrane Collaboration's tool for assessing risk of bias (Table A through G in Appendix S1).

3.5 | Smoking cessation guidelines

The majority of guidelines for smoking cessation interventions have been produced and distributed about two decades ago. Among them, the influence of the clinical practice guideline by the U.S. Department of Health and Human Services for the treatment of tobacco use and dependence (2000, 2008 update) on all human health services has been ongoing (Table 1) (Fiore, 2000; Fiore et al., 2008). These guidelines had a significant impact on the majority of all the subsequent guidelines adopted for all health professionals within their respective countries.

3.6 | Smoking cessation in periodontitis patients

Detailed outcomes of the six included publications are presented in Table 2. Six clinical studies reported on the impact of smoking cessation interventions in periodontitis patients (Bassetti et al., 2017; Binnie et al., 2007; Kropff et al., 2016; Preshaw et al., 2005; Rosa et al., 2014; Schoonheim-Klein et al., 2013). Their research protocols were heterogeneous with study durations from 6 to 24 months and sample sizes between 49 and 469 patients. Due to noticeable ethical reasons, no RCTs were conducted. With the exception of one trial (Bassetti et al., 2017), moderate quit rates between 4% at a one-year follow-up (Binnie et al., 2007) and 30% at a two-year follow-up (Rosa et al., 2014) were reported. Secondary outcomes revealed (a) higher quit rates following more intensive behavioural support and (b) improvements of periodontal parameters such as increased periodontal probing depth (PD) reduction (Preshaw et al., 2005; Rosa et al., 2014) and less clinical attachment loss (CAL) (Rosa et al., 2014) in former smokers when compared to smokers and oscillators.

3.7 | Diabetes control guidelines

The "Guidelines for the prevention, management and care of diabetes mellitus" have been published by the World Health Organization

in 2006 (Table 1) (WHO, 2006). More recently, updated guidelines have been produced and distributed for diabetes self-management education by both Powers et al. (2016) and the U.S. Department of Veterans Affairs/U.S. Department of Defence (2017) (Powers et al., 2016; VA/DoD, 2017).

3.8 | Diabetes control in periodontitis patients

Three publications presented the effect of diabetes control interventions in periodontitis patients (Holmer et al., 2018; Nishihara et al., 2017; Saengtibovorn & Taneepanichskul, 2015). The interventions mainly consisted of individual lifestyle counsellings including dietary changes and oral health education. The studies lasted either 4 weeks or 6 months, respectively. The former being two RCTs over 6 months with 77 (Nishihara et al., 2017) and 132 patients (Saengtibovorn & Taneepanichskul, 2015) and the latter being a prospective study over 4 weeks with 8 patients (Holmer et al., 2018). Following the intervention, periodontal parameters such as gingival index or bleeding on probing have improved. In one study, PD and CAL have improved after six months (Saengtibovorn & Taneepanichskul, 2015). More detailed results of the three included studies are summarized in Table 3.

3.9 | Physical exercise guidelines

The "Global Recommendations on Physical Activity for Health" and the "National Recommendations for Physical Activity and Physical Activity Promotion" have been produced and distributed by the WHO and the German Federal Ministry of Health, respectively (Table 1) (Rütten & Pfeifer, 2016; WHO, 2010). More recently, additional guidelines have been published by the U.S. Department of Health and Human Services (Azar, 2018). While addressing all healthcare providers, these 2018 guidelines further recommended to adopt interventions specifically targeted for different ages and patient populations.

3.10 | Physical exercise in periodontitis patients

Two clinical studies presented their outcomes from physical exercise (activity) interventions in patients with periodontitis (Omori et al., 2018; Sudhanshu et al., 2017). Distinctly different interventions were used in these two studies (Table 4). While in an RCT over 12 weeks, a total of 40 periodontitis patients were educated with comprehensive yogic interventions followed by yoga exercises (Sudhanshu et al., 2017) another prospective study over 12 weeks investigated 50 patients provided with a briefing followed by physical exercises (Omori et al., 2018). In both studies, patients presented with improved periodontal parameters including bleeding scores and PD after 12 weeks.

TABLE 3 Included studies on diabetes control interventions in patients with periodontitis (in chronological order of their publication)

Study	Type of study and duration	Study settings and industrial funding	Study sample	No. of subjects	Type(s) of intervention	Primary outcome(s)	Secondary outcome(s)	Risk of bias and remarks
(Saengtipbovorn & Taneespanichskul, 2015)	RCT 6 months	Health Centre and University	Periodontitis patients with diabetes	66 intervention 66 control	Intervention group: 20-min lifestyle and oral health education, individual lifestyle counselling, application of a self-regulation manual and individual oral hygiene instruction (at baseline); individual lifestyle counselling and oral hygiene instruction (at 3a months); booster education (at every visit). Control group: routine programme.	Intervention group with significantly lower glycated haemoglobin, fasting plasma glucose, plaque index, gingival index, probing depth and attachment loss.	-	Low
(Nishihara et al., 2017)	RCT 6 months	School of Nursing and University	Periodontitis patients with type 2 diabetes	38 intervention 39 control	120-min intervention programme over 6 months (4 sessions) including information on 1) diabetes management and 2) relationship between diabetes and periodontitis	Intervention group with significant improvements in scores for bleeding on probing, clinic visit, brushing teeth and meal.	Intervention group also exhibited improvements in dental health-related behaviours.	Low
(Holmer et al., 2018)	Prospective study 4 weeks	Hospital and University	Patients with type 2 Diabetes and periodontitis	8	Dietary counselling for the consumption of the Okinawan-based Nordic Diet (OBND®)	Loss of weight and reduction in BOP	Fasting blood glucose values improved	Moderate See this study listed in Table 5 on change of diet.

Abbreviations: BOP, bleeding on probing; RCT, randomized controlled trial.

3.11 | Change of diet guidelines

Clinical guidelines for dietary interventions addressing all healthcare providers have been produced and published by the WHO (Table 1) (WHO, 2004). One additional guideline distributed by the Food and Nutrition Technical Assistance III Project (FANTA) was providing specific information and specific counselling recommendations to be adopted by all healthcare providers (FANTA, 2016).

3.12 | Change of diet in periodontitis patients

A total of seven studies reported their impact of dietary interventions in patients with periodontitis (Table 5) (Fridell et al., 2018; Holmer et al., 2018; Jenzsch et al., 2009; Kondo et al., 2014; Omori et al., 2018; Woelber et al., 2016; Zare Javid et al., 2014). Their research protocols showed increased heterogeneity with study durations from 4 weeks to 12 months and sample sizes between 8 and 71 subjects. With the exception of one study (Zare Javid et al., 2014), following the interventions periodontal parameters such as bleeding indices and PD significantly improved. Detailed outcomes of the seven included publications are presented in Table 5.

3.13 | Carbohydrate (dietary sugar) reduction guidelines

In 2015, the WHO published the clinical guidelines "Sugars intake for adults and children" addressing all healthcare providers and recommending dietary counselling for the reduction in dietary sugars (Table 1) (WHO, 2015).

3.14 | Carbohydrate (dietary sugar) reduction in periodontitis patients

Two clinical trials presented their impact of carbohydrate (dietary sugar) reduction interventions in periodontitis patients (Kondo et al., 2014; Woelber et al., 2016). Their study durations lasted from 4 to 24 weeks while assessing sample sizes between 17 and 30 subjects. Overall, reductions of gingival indices were observed at follow-up. In particular, Woelber et al. (2016) demonstrated improved periodontal conditions in patients with reduced dietary sugars and constantly elevated plaque indices over a period of four weeks (Woelber et al., 2016). More detailed outcomes of the three included publications are summarized in Table 6.

3.15 | Weight loss guidelines

In 1998, weight loss clinical guidelines were produced and distributed by the U.S. National Institute of Health (NIH) recommending the adoption of behavioural strategies following treatment algorithms

(Table 1) (NIH, 1998). More recently, the "European Guidelines for Obesity Management in Adults" and "An Evidence-based Guide for Obesity Treatment in Primary Care" were published for all healthcare providers suggesting the adoption of care pathways or the use of the 5A's counselling framework (assess, advise, agree, assist and arrange) (Fitzpatrick et al., 2016; Yumuk et al., 2015).

3.16 | Weight loss in periodontitis patients

A total of five prospective studies (CCTs) documented their impact of weight loss interventions in patients with periodontitis (Kondo et al., 2014; Martinez-Herrera et al., 2018; Omori et al., 2018; Sales-Peres et al., 2017; Vivekananda & Faizuddin, 2019). Their research protocols were heterogenous with study durations between 12 weeks and 18 months and sample sizes of 17 to 100 subjects, respectively. The interventions assessed showed various intensities ranging from (a) a briefing followed by dietary change (Omori et al., 2018) to (b) an 8-week high-fibre, low-fat diet (Kondo et al., 2014) to (c) a weight reduction programme with diet and exercise-related lifestyle modifications (Vivekananda & Faizuddin, 2019). With two exceptions (Omori et al., 2018; Sales-Peres et al., 2017), periodontal parameters such as gingival indices, PD and CAL improved until follow-up. The detailed outcomes of these five included publications are summarized in Table 7.

4 | DISCUSSION

Following a systematic search in the literature, a total of 13 widely accepted guidelines for risk factor control interventions were selected. These counselling interventions included smoking cessation, diabetes control, physical exercise (activity), change of diet, carbohydrate (dietary sugar) reduction and weight loss. With a subsequent second systematic search, 28 studies were included evaluating the impact of these interventions in patients with periodontitis. In relation to the effects on the periodontal condition in periodontitis patients, the present systematic review indicates a moderate to high effectiveness of smoking cessation and dietary counselling, whereas the impact of diabetes control, physical exercise (activity), carbohydrate (dietary sugar) reduction and weight loss on periodontal condition was limited.

Upon aiming to improve periodontal treatment outcomes and the maintenance of periodontal health, earlier evidence from a narrative review on the impact of subject-based risk factor control on periodontitis suggested that second to improving oral hygiene, smoking cessation was the most important part of periodontal therapy (Ramseier, 2005). In a more recent systematic review on the promotion of healthy lifestyles, smoking cessation was shown to be effective when applied in the dental practice while further evidence for dietary counselling in the dental setting was limited (Ramseier & Suvan, 2015). Following the assessment of 28 clinical studies, the present systematic review reveals that previous evidence for risk

TABLE 4 Included studies on physical exercise (activity) interventions in patients with periodontitis (in chronological order of their publication)

Study	Type of study and duration	Study settings and industrial funding	Study sample	No. of subjects	Type(s) of intervention	Primary outcome	Secondary outcome(s)	Risk of bias and remarks
(Sudhanshu et al., 2017)	RCT 12 weeks	Hospital and University -	Periodontitis patients	40 yoga group (test) 40 control	Comprehensive yogic intervention followed by yoga exercises	Test group presented with reduced plaque scores, bleeding scores, PD and less CAL.	Cohen's perceived stress scale score significantly improved in test group.	Low Improvements are attributed to stress reduction through yoga session.
(Omori et al., 2018)	Prospective study 12 weeks	Hospital and University -	Obese male with periodontitis	50 exercise intervention group 21 dietary intervention group	Briefing followed by physical exercises	Exercise intervention group presented with less PD \geq 4mm, BOP% and lowered counts of <i>Tannerella forsythia</i> and <i>Treponema denticola</i> .	Dietary intervention group presented with lowered counts of <i>Treponema denticola</i> ; however, no correlation between the number of periodontitis-causing bacteria and PD and BOP was found.	Moderate See this study listed in Table 5 on dietary changes.

Abbreviations: BOP; bleeding on probing; CAL, clinical attachment loss; PD, probing depth; RCT, randomized controlled trial.

factor control interventions for smoking cessation was strengthened and more evidence for the efficiency of dietary counselling was established specifically in patients with periodontitis. In brief, over the past two decades evidence for the need of counselling interventions has emerged while the efficiency of these interventions has increased. Consequently, in patients with periodontitis, next to improving oral hygiene and supporting smokers to quit, the promotion of healthy lifestyles, such as dietary counselling, needs to be adopted in everyday periodontal care.

So far, current evidence for the efficiency of dietary interventions in periodontitis patients has been moderate when studies were selected assessing one single aspect of the intervention such as carbohydrate (dietary sugar) reduction alone. Furthermore, counselling intervention studies mainly focussing on weight loss generally included multiple aspects such as dietary changes or the increase in physical activity (exercise). Similarly, risk factor control interventions in periodontitis patients with type 2 diabetes commonly involved combinations of dietary counselling, physical exercise and weight loss. Accordingly, with this systematic review, several studies were qualifying for more than one risk factor control intervention such as physical exercise (activity) and dietary changes (Omori et al., 2018) or weight loss, carbohydrate (dietary sugar) reduction and dietary interventions (Kondo et al., 2014), respectively. Clinical studies specifically targeting the counselling intervention of one single risk factor were sparse or non-existent possibly even due to ethical reasons. Consequently, most clinical practice guidelines selected for this systematic review suggested to adopt comprehensive approaches and further inter-professional measures in order to tackle several risk factors for chronic or noncommunicable diseases.

Numerous risk factors associated with periodontitis are overlapping and intensifying each other. Additionally, the proximity of the risk factor may have an impact on the causality (Bouchard, Carra, Boillot, Mora, & Range, 2017). Moreover, interventions for physical exercise (activity), change of diet, carbohydrate reduction and weight loss may be both interrelated and interdependent. Interestingly, in the study by Sudhanshu et al. (2017) it remained unclear whether a yogic intervention provided had a positive impact on periodontal health due to the increase in physical activity or due to the yoga-induced stress reduction as it was suggested by the authors (Sudhanshu et al., 2017). Consequently, while adopting a holistic approach, an inter-professional collaboration conducted by a team of healthcare providers such as physicians, nutritionists and psychologists may need to be considered (WHO, 2006). However, studies demonstrating the benefit of this collaboration are lacking in periodontal medicine. Moreover, it seems to be critical for risk factor control interventions to be delivered by the dental team since previous research investigating the effects of counselling delivered by external psychologists were unable to find additional benefits (Stenman, Lundgren, Wennstrom, Ericsson, & Abrahamsson, 2012; Zare Javid et al., 2014). According to the available evidence today, even though collaborative multidisciplinary approaches for healthy lifestyle interventions are promoted by widely accepted guidelines, their impact in patients with periodontitis limited or non-existent.

TABLE 5 Included studies on dietary interventions in patients with periodontitis (in chronological order of their publication)

Study	Type of study and duration	Study settings and industrial funding	Study sample	No. of subjects	Type(s) of intervention	Primary outcome(s)	Secondary outcome(s)	Risk of bias and remarks
(Jenzsch et al., 2009)	Prospective clinical study 12 months	University -	Patients with metabolic syndrome and chronic periodontitis	20 females	One-year guided nutritional intervention programme: consultations to implement a wholesome nutrition every 2 weeks (first 2 months) followed by consultations every 2 months.	Reduction in PD, GI, reduced concentrations of IL-1 β , IL-6 in GCF.	Bacterial counts in GCF as well as oxidative and antioxidative variables in saliva showed no significant changes. Only salivary catalase showed a tendency to lower values	Moderate -
(Kondo et al., 2014)	Prospective study 24 weeks	Hospital and University -	Periodontitis patients with a body mass index of at least 25.0 kg/m ² or with impaired glucose tolerance	17	8 weeks of a high-fibre, low-fat diet intervention (test-meal period)	PD, CAL and BOP% showed significant reductions after the test-meal period (8 weeks). These improvements persisted during the follow-up period (24 weeks).	Body weight, HbA1c and high-sensitivity C-reactive protein levels showed improvement after the test-meal period; they returned to baseline levels after the follow-up period.	Moderate See this study listed in Table 6 on carbohydrate (dietary sugar) reduction and in Table 7 on weight loss.
(Zare Javid et al., 2014)	RCT 6 months	Dental Hospital and University -	Periodontitis patients	18 intervention 19 control	Periodontal treatment with dietary intervention by community nutrition assistant for the implementation of a balanced diet.	No between-group differences were found with respect to periodontal indices.	Intervention group showed an increase in plasma total antioxidant capacity.	Low
(Woelber et al., 2016)	RCT 4 weeks	University -	Gingivitis and periodontitis patients	10 experimental 5 control	Dietary intervention for the reduction in carbohydrates (dietary sugars) and the increase in Omega-3 fatty acids, vitamins C and D, antioxidants and fibres.	Gingival index, BOP% and PISA were significantly reduced in the experimental group.	Plaque index remained constant in both groups	Low See this study listed in Table 6 on carbohydrate (dietary sugar) reduction.
(Fridell et al., 2018)	Randomized study 8 weeks	University -	Non-obese patients with periodontitis	15 fruit group 15 nut group	Dietary intervention for the implementation of a fruit- and nut-rich diet	PD \geq 4mm was reduced in the fruit& nut group both within-group and between-group	-	Low

(Continues)

TABLE 5 (Continued)

Study	Type of study and duration	Study settings and industrial funding	Study sample	No. of subjects	Type(s) of intervention	Primary outcome(s)	Secondary outcome(s)	Risk of bias and remarks
(Omori et al., 2018)	Prospective study 12 weeks	University -	Obese male with periodontitis	21 dietary intervention group 50 exercise intervention group	Dietary restriction intervention programme provided lectures and consultations on nutrition and dietary habits once a week for 90 min.	Dietary intervention group presented with lowered counts of <i>Treponema denticola</i> ; however, no correlation between the number of periodontitis-causing bacteria and PD and BOP was found.	Exercise intervention group presented with less PD \geq 4mm, BOP% and lowered counts of <i>Tannerella forsythia</i> and <i>Treponema denticola</i> .	Moderate See this study listed in Table 4 on physical exercise and in Table 7 on weight loss.
(Holmer et al., 2018)	Prospective study 4 weeks	Hospital and University -	Patients with type 2 Diabetes and periodontitis	8	Dietary counselling for the consumption of the Okinawan-based Nordic Diet (OBND®)	Loss of weight and reduction in BOP	Fasting blood glucose values improved	Moderate See this study listed in Table 3 on diabetes control.

Abbreviations: BOP, bleeding on probing; GCF, gingival crevicular fluid; GI, gingival index; IL, interleukin; PD, probing depths; PISA, periodontal inflamed surface area.

TABLE 6 Included studies on carbohydrate (dietary sugar) reduction interventions in patients with periodontitis (in chronological order of their publication)

Study	Type of study and duration	Study settings and industrial funding	Study sample	No. of subjects	Type(s) of intervention	Primary outcome(s)	Secondary outcome(s)	Risk of bias and remarks
(Kondo et al., 2014)	Prospective study 24 weeks	Hospital and University -	Periodontitis patients with a body mass index of at least 25.0 kg/m ² or with impaired glucose tolerance	17	8 weeks of a high-fibre, low-fat diet intervention (test-meal period)	PD, CAL and BOP% showed significant reductions after the test-meal period (8 weeks). These improvements persisted during the follow-up period (24 weeks).	Body weight, HbA1c and high-sensitivity C-reactive protein levels showed improvement after the test-meal period; they returned to baseline levels after the follow-up period.	Moderate See this study listed in Table 5 on change of diet.
(Woelber et al., 2016)	RCT 4 weeks	University -	Gingivitis and periodontitis patients	10 experimental 5 control	Dietary intervention for the reduction in carbohydrates (dietary sugars) and the increase in Omega-3 fatty acids, vitamins C and D, antioxidants and fibres.	Gingival index, BOP% and PISA were significantly reduced in the experimental group.	Plaque index remained constant in both groups	Low See this study listed in Table 5 on change of diet.

Abbreviations: BOP, bleeding on probing; PD, probing depth; PI, plaque index.

TABLE 7 Included studies on weight loss interventions in patients with periodontitis (in chronological order of their publication)

Study	Type of study and duration	Study settings and industrial funding	Study sample	No. of subjects	Type(s) of intervention	Primary outcome(s)	Secondary outcome(s)	Risk of bias and remarks
(Kondo et al., 2014)	Prospective study 24 weeks	Hospital and University -	Periodontitis patients with a body mass index of at least 25.0 kg/m ² or with impaired glucose tolerance	17	8 weeks of a high-fibre, low-fat diet intervention (test-meal period)	PD, CAL and BOP% showed significant reductions after the test-meal period (8 weeks). These improvements persisted during the follow-up period (24 weeks).	Body weight, HbA1c and high-sensitivity C-reactive protein levels showed improvement after the test-meal period; they returned to baseline levels after the follow-up period.	Moderate See this study listed in Table 6 on carbohydrate (dietary sugar) reduction and in Table 5 on change of diet.
(Sales-Peres et al., 2017)	Prospective study 12 months	University -	Morbidly obese patients with periodontitis after bariatric surgery	110	Dietary counselling prior to bariatric surgery	The greater the BMI loss, the higher the proportion of sites with BOP. No change in PD and CAL.	-	Moderate No dietary counselling for the duration of the study.
(Martinez-Herrera et al., 2018)	Prospective study 12 weeks	Hospital and University -	Obese patients with periodontitis	31 with diet 47 without diet	Dietary therapy consisted of a 6-week very low-calorie diet. After 6 weeks, a low-calorie diet (1,200 kcal/day for women and 1,500 kcal/day for men) containing 55% carbohydrate, 30% fat and 15% protein was administered for the following next 6 weeks.	PD significantly improved in dietary group.	Complement component 3 (C3) and TNF- α decreased in the dietary group after intervention.	Moderate -
(Omori et al., 2018)	Prospective study 12 weeks	Hospital and University -	Obese male with periodontitis	21 dietary intervention group 50 exercise intervention group	Dietary restriction intervention programme provided lectures and consultations on nutrition and dietary habits once a week for 90 min.	Dietary intervention group presented with lowered counts of <i>Treponema denticola</i> ; however, no correlation between the number of periodontitis-causing bacteria and PD and BOP was found.	Exercise intervention group presented with less PD \geq 4mm, BOP% and lowered counts of <i>Tannerella forsythia</i> and <i>Treponema denticola</i> .	Moderate See this study listed in Table 4 on physical exercise and in Table 5 on change of diet.
(Vivekananda & Faizuddin, 2019)	Prospective study 18 months	Hospital and University -	Obese subjects with gingivitis or periodontitis (gingivitis) 20 group 1 (healthy) 20 group 2 (gingivitis) 20 group 3 (periodontitis)	20 group 1 (healthy) 20 group 2 (gingivitis) 20 group 3 (periodontitis)	Weight reduction programme with diet and exercise-related lifestyle modifications	Subjects with \geq 10% reduction in body weight resulted in elevated serum adiponectin and reduced serum TNF- α .	In group 3, weight reduction resulted in improved PD and CAL.	Moderate -

Abbreviations: BOP, bleeding on probing; CAL, clinical attachment loss; PD, probing depth; TNF- α , tumour necrosis factor alpha.

Periodontitis patients benefit from additional risk factor control interventions in order to improve periodontal treatment outcomes and the maintenance of periodontal stability. However, even though a limited number of 13 widely accepted guidelines for risk factor control interventions were identified with the present systematic review, many more different counselling strategies were described in the literature. Therefore, conducting meta-analyses for a total of six risk factors and their respective interventions was not indicated with the clinical studies selected in the present systematic review. Moreover, in most of the studies assessing various associations with periodontal health such as improved glycaemic control or reduced body weight, no counselling interventions were performed. For this reason, several studies needed to be excluded (Baumgartner et al., 2009; Costa et al., 2013; Saengtibovorn & Taneepanichskul, 2014). In summary, it remains inconclusive as for which counselling approach might be beneficial for specific risk factor control interventions and thus indicated with periodontitis patients.

A few limitations of the present systematic review need to be discussed. In general, both internationally and nationally accepted guidelines for risk factor control interventions have been produced and distributed for all healthcare providers. Therefore, specific guidelines, for example for diabetes control often include pharmacological support prescribed by the physician (Qaseem, Barry, Humphrey, & Forciea, 2017). Furthermore, interventions for weight loss may include additional pharmacological support (Apovian et al., 2015) or surgical interventions (Snow et al., 2005) which may temporarily deteriorate the periodontal condition (Fontanille et al., 2018). Such interventions will not be provided by the periodontal care team alone and thus need both collaboration with and referral to additional health care providers.

The overall quality of evidence was found to be low or minimal, and most of the selected intervention studies were at a medium or high risk of bias. Moreover, with the studies selected for this systematic review, a high level of heterogeneity was observed concerning study designs including both intervention type and study duration.

A few suggestions for further research could be mentioned. Future clinical studies investigating the impact of various risk factor control interventions need to give more detailed information about the process of the counselling being applied. Specifically, the underlying mechanisms need to be further investigated concerning the use of empathic or reflective language or the methods on how to increase awareness, change talk and self-efficacy in the patients enrolled (Kitzmann, Ratka-Krueger, Vach, & Woelber, 2019). Moreover, due to the recent emphasis in global campaigns aiming for the reduction in refined (dietary) sugars and carbohydrates on a population level (von Philipsborn et al., 2019) there appears to be a need for more intensive research about personalized counselling approaches as well as the potential benefits of a single carbohydrate (dietary sugar) reduction in patients suffering from those consequences of increased intake of refined sugars such as diabetes type 2 and periodontitis.

In addition to the need of intervention studies for carbohydrate (dietary sugar) reduction, there appears to be a need for further

studies on changes of micronutrients intake (Van der Velden et al., 2011) or alcohol reduction (Wang, Lv, Wang, & Jiang, 2016), respectively (Hujoel & Lingstrom, 2017). Furthermore, with both dietary intervention studies, for example for carbohydrate (dietary sugar) reductions and weight loss, it may be recommended to implement food diaries along with the counselling interventions (Kondo et al., 2014; Omori et al., 2018; Woelber et al., 2016, 2019). These recommendations are in line with earlier recommendations emphasizing the benefits of self-monitoring in studies with self-administered plaque control (Newton & Asimakopoulou, 2015).

In conclusion, current evidence on the effect of health behaviour interventions in periodontal care suggests that interventions for smoking cessation and diabetes control are effective, thus emphasizing the need of behavioural support in periodontal care.

While different policies and recommendations may be adopted in periodontal settings throughout different countries, a common risk factor approach may generally be suggested in all future clinical practice guidelines adopting risk factor control interventions into professional periodontal care (Sheiham & Watt, 2000). The promotion of healthy lifestyle should take place within a framework of evidence-based behaviour change interventions. Consequently, an interdisciplinary collaboration of both researchers and clinicians may need to be established and thus periodontal care providers may consider adopting a referral system to improve future evidence-based periodontal care and their patients' quality of life.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest in this study.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Ramseier CA, Woelber JP, Kitzmann J, Detzen L, Carra MC, Bouchard P. Impact of risk factor control interventions for smoking cessation and promotion of healthy lifestyles in patients with periodontitis: A systematic review. *J Clin Periodontol*. 2020;47:90–106. <https://doi.org/10.1111/jcpe.13240>