Available online www.ijpras.com

International Journal of Pharmaceutical Research & Allied Sciences, 2021, 10(2):94-102
https://doi.org/10.51847/8RpiSiVJRG

Research Article

ISSN : 2277-3657
CODEN(USA) : IJPRPM

Lifestyle Interventions Reduce the Risk of Type II Diabetes and Cardiovascular Diseases Development among Pre-diabetic Adults

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ABSTRACT

This paper evaluated the effectiveness of community-based nutrition and physical activity program to change physical activity, dietary behavior, glucose level, and some metabolic parameters among adults aged 50-65 with pre-diabetes after a six-month intervention. Participants who were pre-diabetics and had at least 2 components of Metabolic Syndrome (MetS) in Hanam province, Vietnam were randomly assigned into the intervention (n=44) and control (n=49) groups. The intervention group received a health promotion package, whereas the control received 1 session of standard advice during six months.
Results showed that there were significant increases in the intervention group for physical activity outcomes, including moderate activity, walking time, total physical activity, and mean sitting time. A significant difference was also observed between intervention and control groups at post-test in walking time, total physical activity, and sitting time. For dietary behaviors, frequent use of salt was decreased significantly after 6 months for both groups while the intervention group's frequent intake of cooking oil was significantly reduced. Regarding fasting glucose level and other metabolic parameters after 6-month intervention, reduction in fasting glucose level were found in the intervention but increased in the control group. Significant improvement in HDL-C and diastolic blood pressure among the intervention in comparison to the control group was reported. A significant reduction in weight in the intervention group in comparison with the control group was also found after the 6-month intervention. This program successfully improved dietary behaviors and physical activity, fasting glucose level, and cardiovascular risk among adults with pre-diabetes in Vietnam.

Key words: *Physical activity, Diet, Diabetes, Cardiovascular diseases, Lifestyle intervention, Vietnam*

INTRODUCTION

Type II diabetes (T2D) [1] and cardiovascular diseases (CVDs) [2] are now a heavy burden worldwide and in Vietnam. CVDs are the major cause of death in Vietnam, responsible for 31% of total death in 2016 in the country [3]. Regarding T2D, it is estimated that approximately 6% of the Vietnamese population have diabetes in 2017, equivalent to almost 6 million diabetic cases in Vietnam [4, 5]. It is projected that more people in Vietnam will experience CVDs and T2D in the near future and suggest that the health system in Vietnam should pay extra effort to prevent risk factors of those health problems [4].
Metabolic Syndrome (MetS) is described as a group of risk factors for CVD, T2D, and all-cause mortality. It includes abdominal obesity, hypertension, high glucose concentrations, elevated fasting triglyceride, and reduced HDL-C [6]. Literature showed that MetS increases 2-fold in cardiovascular outcomes, 1.5-fold all-cause mortality,

and 5-6-fold increased risk of T2D [7]. Researches estimated that 25% of adults worldwide suffer from the condition [8]. The accurate data may be higher as MetS is often undiagnosed [8]. In Vietnam, MetS is prevalent among middle-aged adults with almost two-fifths of them having MetS. A higher prevalence of MetS was reported among older adults aged 55-64 in Vietnam, accounting for 27% of the group [9].

Lifestyle intervention, combining physical activity (PA) and dietary modification, has been reported as the cornerstone method to reduce CVDs and T2D risk [10]. Previous studies demonstrated that structured lifestyle intervention reduced the risk factors for CVDs, including systolic and diastolic blood pressure, triglycerides, HDL-C, LDL-C, and total cholesterol [10, 11]. In addition, literature has confirmed the effectiveness of the interventions, which motivate participants to improve lifestyle behaviors and weight management for controlling MetS [12].

Vietnam Physical Activity and Nutrition (VPAN) program is a lifestyle intervention program consisting of physical activity and nutrition intervention for adults 50-65 years old with MetS in Hanam province in the North of Vietnam. This cluster randomized controlled trial has been registered with New Zealand and Australia Clinical Trial Registry (ACTRN12614000811606). Details of the intervention program have been described previously [13].

This paper aimed to analyze the effectiveness of the VPAN program in terms of changing PA level, dietary behavior, fasting glucose level, and some metabolic parameters among the pre-diabetic participants after the six-month intervention.

MATERIALS AND METHODS

Study design

This intervention program was a cluster-randomized community-based 6-month controlled trial targeting adults aged 50-65 years with MetS in Hanam province, north of Vietnam. The program in detail has been published elsewhere [13].

Studied participants

In this paper, we analyzed 93 pre-diabetic adults aged 50-65 years (intervention group: 44 participants), (control group: 49 participants) who completed the 6-month intervention.

Inclusion criteria

The participants were pre-diabetes (fasting plasma glucose (≥6.1mmol/L) and had at least two components of MetS status according to the modified National Cholesterol Education Program Adult Treatment Panel III criteria [14] as below: 1) large waist circumference (female ≥80 cm, male ≥90 cm for Asian Population (4); 2) raised triglyceride (150 mg/dL or ≥1.7 mmol/L); 3) reduced HDL-C (female 50 mg/dL or <1.29 mmol/L, male 40 mg/dL or <1.03 mmol/L) and 4) elevated blood pressure (diastolic ≥85 mmHg or systolic ≥130 mmHg).

Exclusion criteria

Adults suspected of T2D (fasting plasma glucose ≥7.1 mmol/L); taking or undergoing treatment for T2D, CVD, dyslipidemia, hypertension, and hyperglycemia; or involvement in PA and/or dietary program within the past year were excluded from the study.

Interventions

Details of the interventions were described previously [13]. In short, the Social Cognitive Theory underpinned the intervention development [15], designing to promote participants to maintain a healthy diet and be physically active. The interventions of the VPAN program included four 2-hour education sessions, walking groups a resistance band, and a booklet.

Instruments

Personal and demographic information such as marital status, occupation, gender, age, alcohol consumption, and smoking was obtained using a questionnaire given to participants via face-to-face interview at the beginning of the study.

Physical activity

PA levels including moderate-intensity activity, vigorous-intensity activity, sitting, and walking time were measured using the International Physical Activity Questionnaire-Short Form, validated for Vietnamese adults [16].

Diet

The brief dietary habits questionnaire was modified from the STEPs questionnaire developed by the WHO [17] to gather information on the consumption of vegetables and fruits, intake of animal internal organs, and the frequency of using cooking oil and salt for preparing meals.

Metabolic outcomes

Metabolic outcomes were blood parameters, blood pressure. They measured at baseline and post-test. Fasting blood samples were taken by a phlebotomist at commune health stations. Fasting plasma glucose, total cholesterol, HDL-C, and triglyceride concentrations were measured, and LDL-C and non-HDL-C levels were subsequently calculated [18].

Blood pressure and anthropometric measurements were taken by trained program staff following the WHO's guidelines [17]. The mean value of systolic and diastolic blood pressures was measured after taking 3 consecutive measurements.

Anthropometric outcomes

Waist and hip circumferences were recorded, and waist-to-hip ratio (WHR) was subsequently determined. Weight was recorded to the nearest 0.01kg, and height was recorded to the nearest 0.1cm.

Statistical analysis

Descriptive statistics were first applied to summarize the characteristics of the cases by the status of the group. Participants in the two groups were compared at two time points using independent samples and chi-square test for dichotomous outcomes and paired t-tests for continuous outcome variables. Wilcoxon signed-rank test and Mann-Whitney U test were also applied for variables with skewed distributions.

RESULTS AND DISCUSSION

This study offered a community-based intervention program in terms of PA levels and dietary patterns to assess the intervention efficiency to adults with high risks of T2D and CVDs. The results reported significant improvements in PA and nutrition outcomes among intervention participants compared to the controls, which was consistent with previous studies with similar strategies [19]. Other substantial changes in MetS components and anthropometrics can also be seen in both groups.

Table 1. Baseline characteristics of participants in control and intervention groups

Variable	Intervention (n=44) n (%)	Control (n=49) n (%)	p
Age: mean (SD) years	58.6 (4.6)	56.7 (4.4)	0.053
Gender			
Female	35 (79.5)	32 (65.3)	0.127
Male	9 (20.5)	17 (34.7)	
Education level			0.124
Primary school or below	2 (4.5)	6 (12.2)	
Secondary school	22 (50.0)	29 (59.2)	
High school	17 (38.6)	8 (16.3)	
College/University	3 (6.8)	6 (12.2)	
Occupation			0.132
Farmer/worker	6 (13.6)	16 (32.6)	
Office job	0 (0)	2 (4.1)	
Retired	16 (36.4)	12 (24.5)	

Business	6 (13.6)	5 (10.2)	
Home duties and others	16 (36.4)	14 (28.5)	
Smoking status			0.825
Never	38 (86.4)	40 (81.6)	
Former	4 (9.1)	6 (12.2)	
Current smoker	2 (4.5)	3 (6.1)	
Alcohol drinking			0.212
No	37 (84.1)	36 (73.5)	
Yes	7 (15.9)	13 (26.5)	

Table 1 presents the characteristics of the participants for the 6-month intervention. There was no significant difference between the two groups (p>0.05) in baseline characteristics of the cases. The mean age was 56.8 (SD 4.6) years in the intervention group and 56.7 (SD 4.4) in control participants, most of whom were females. A large number of participants completed secondary school or higher (90%). Almost 35% of the cohort had retired. More than 84.1% of the intervention sample and 73.5% of the control sample had no smoking. Most participants in both groups had no smoking (86.4% in the intervention group and 81.6% in the control group).

Table 2. Comparison of physical activity outcomes over time and between intervention and control groups

Outcomes	**Intervention (n=44)**		**p**[1]	**Control (n=49)**		**p**[2]	**p**[3]	**p**[4]
	Baseline (%)	Post n (%)		Baseline n (%)	Post n (%)			
Vigorous activity [a]	4 (9.1)	8 (18.2)	0.214	5 (10.2)	11 (22.4)	0.101	0.569	0.610
Moderate activity [a]	12 (27.3)	21 (47.7)	0.048	12 (24.5)	18 (36.7)	0.188	0.759	0.283
Walking time: mean (SD) [b]	395.2 (554.2)	630.6 (539.4)	0.015	333.6 (394.3)	326.7 (355.0)	0.680	0.567	0.002
Total physical activity: mean (SD) [b]	545.7 (666.3)	773.3 (557.1)	0.018	448.4 (447.9)	502.9 (496.6)	0.260	0.951	0.009
Sitting time: mean (SD) min/week	2,529.9 (656.7)	1,902.7 (934.1)	<0.001	2,568.9 (831.0)	2499.4 (940.7)	0.697	0.494	0.007

[1] Between baseline and post-test for the intervention group
[2] Between baseline and post-test for the control group
[3] Between control and intervention groups at baseline
[4] Between control and intervention groups at post-test
[a] Participation of at least ten minutes
[b] Nonparametric test applied to MET-min/week

PA levels of the two groups at baseline and posttest are shown in **Table 2**. No significant differences were observed between post-test and baseline for the control group and between control and intervention groups at baseline. There were significant improvements in moderate, walking, total PA, and sitting time in the intervention group at post-test. Evidence showed that too much sitting had adverse cardiovascular and metabolic effects on adults whether or not PA guidelines were met [20, 21], so combining both increased PA levels and reduced sitting time is an essential element for future intervention programs. Significant differences were observed between control and intervention groups at post-test, walking time, total PA, and sitting time (p<0.05), while changes in vigorous and moderate activities were not significant. The increase of PA levels in this study contributes to existing evidence on the effectiveness of PA interventions that was reported in other studies [21, 22]. However, there are differences in the intervention strategies used, which could be problematic to decide which approach would be the most favored one for a targeted group. Our study adopted the WHO's Recommendations for Physical Activity [23], tailored the program to suit individual goals and needs, and created a motivational environment for the participants to follow and enhance their adherence. The main PA established in this study was walking, which was confirmed to be the most frequent and the safest form of PA, especially for older people [24]. In part, these efforts might explain the positive changes in PA behaviors of the intervention group.

Table 3. Dietary behavior outcomes over time and between control and intervention groups

Outcome	Intervention (n=44)		p^1	Control (n=49)		p^2	p^3	p^4
	Baseline n (%)	Post n (%)		Baseline n (%)	Post n (%)			
Frequent vegetable intake [a]	39 (88.6)	37 (84.1)	0.534	44 (89.8)	36 (73.5)	0.037	0.559	0.213
Frequent fruit intake [a]	17 (38.6)	17 (38.6)	1.000	8 (16.3)	12 (24.5)	0.316	0.015	0.141
Frequent use of cooking oil [a]	13 (29.5)	5 (11.4)	0.034	14 (28.6)	12 (24.5)	0.647	0.918	0.116
Frequent use of salt [a]	40 (90.9)	15 (34.1)	<0.001	48 (98.0)	31 (63.3)	<0.001	0.186	0.005
Frequent intake of animal internal organs [b]	35 (79.5)	35 (79.5)	1.000	35 (71.4)	29 (59,2)	0.203	0.365	0.034

[1] Between baseline and post-test for the intervention group
[2] Between baseline and post-test for the control group
[3] Between control and intervention groups at baseline
[4] Between control and intervention groups at post-test
[a] At least once/day
[b] More than twice/month

Dietary behavior outcomes were shown in **Table 3**. Healthy dietary patterns provided in this intervention program followed the Food-Based Dietary Guidelines in Vietnam [25], which included advice on higher fruit and vegetable consumption while reducing red meat, salt, and fat intakes. Between control and intervention groups at baseline, there were no significant differences. Frequent use of salt for preparing meals was apparently decreased from baseline to post-test for both groups (p<0.001). In addition, daily use of cooking oil reduced significantly in the intervention group (p=0.034). These improvements provide further support for nutrition programs aimed at people with or at high risk of CVD development, given the relationship between dietary fat intake [26] and salt intake [27] with components of MetS. Unfortunately, no significant changes were found in daily fruit and vegetable intakes in both groups. This result was controversial with findings from a study that showed the enhancement of fruits and vegetable consumption after a 10-week nutrition education intervention [28]. The “ceiling effect” might limit improvements in this study [29], because the participants were already maintaining a dietary scheme with intakes of these foods at least once per day. We noticed a difference in the consumption of animal internal organs between the two groups with higher prevalence in the intervention group (79.5%) compared with their control counterparts (59.2%) at post-test. The difference may refer to the participants' dietary habits that we, unfortunately, had no access to discuss further.

Table 4. Comparison of changes in glucose level and other metabolic parameters between control and intervention groups

Outcome	Intervention (n=44)		p^1	Control (n=49)		p^2	p^3	p^4
	Baseline Mean (SD)	**Post-test** Mean (SD)		**Baseline** Mean (SD)	**Post-test** Mean (SD)			
Glucose (mM)	6.6 (0.36)	6.4 (1.77)	0.518	6.6 (0.32)	7.3 (2.75)	0.120	0.450	0.117
HDL-C (mM)	1.4 (0.20)	1.6 (0.67)	0.116	1.6 (0.38)	1.4 (0.26)	0.004	0.171	0.025
Total cholesterol (mM)	5.1 (0.94)	5.8 (1.28)	0.017	5.3 (0.84)	5.5 (0.95)	0.128	0.259	0.344
Triglycerides (mM) [a]	2.1 (1.3)	2.3 (1.2)	0.420	2.5 (1.6)	2.7 (2.2)	0.490	0.113	0.783
Non-HDL-C (mM)	3.6 (0.95)	4.1 (1.52)	0.125	3.7 (0.87)	4.1 (0.85)	0.012	0.502	0.997
LDL-C (mM)	2.7 (0.78)	3.1 (1.44)	0.163	2.4 (1.34)	2.9 (1.30)	0.113	0.733	0.546
Systolic blood pressure (mmHg)	134.4 (17.14)	131.4 (18.10)	0.363	133.9 (15.61)	135.5 (20.59)	0.604	0.864	0.369

Diastolic blood pressure (mmHg)	82.2 (10.41)	80.1 (10.78)	0.362	85.3 (12.71)	89.6 (12.2)	0.032	0.258	0.001

[1] Between post-test and baseline for the intervention group
[2] Between post-test and baseline for the control group
[3] Between control and intervention groups at baseline
[4] Between control and intervention groups at post-test
[a] Non-parametric tests applied due to skewed distributions

Table 4 demonstrates the changes in glucose level and other metabolic parameters in intervention and control groups after the 6-month intervention. We found that fasting plasma glucose level in the intervention group decreased (-0.2mM, p=0.518) at post-test but that of the controls increased (+0.7mM, p=0.12). However, no significant differences at post-test were found between the two groups. The finding of this study was consistent with a report from a study of Oldroyd *et al.* [30] with similar lifestyle modifications for improving health in individuals with impaired glucose tolerance, which showed an insignificant reduction in glucose (-0.11mM, p=0.63) between the control and intervention groups. Another 10-week intervention of daily walking also showed no significant decrease in fasting plasma glucose after the intervention [31]. This outcome indirectly recommends that the efficacy of lifestyle modification on diabetes prevention might be mediated by the role of pre-diabetes phenotypes (in terms of impaired glucose tolerance and/or fasting glucose), each with distinct underlying pathophysiology related to the presence or absence of insulin resistance [32, 33]. However, changes in glucose levels were encouraging. Longer intervention may have better changes in glucose level among the at risk group.

There was an unexpected increase in total cholesterol (+0.7 mM, p=0.017), while no changes were found in other metabolic components in the intervention group. Otherwise, other studies demonstrated the role of exercise in lowering triglycerides, blood pressure, total cholesterol, and LDL-C concentration [34, 35]. Significant differences in the present study, however, can be seen in the control group with the decreased HDL-C concentration (-0.2 mM, p=0.004) and the increased diastolic blood pressure (+4.3 mM, p=0.032). Statistical significance was also found in mean HDL-C (+0.2mM, p=0.025) and diastolic blood pressure (+9.5mmHg, p=0.001) between the control and intervention groups at post-test. The unclear and contrary effectiveness of the interventions for the changes of MetS components could be explained by the fact that the participants were all people at high risk for T2D and CVD developments, and the limited time of intervention program, as well as the deficient intensity of physical activities, can inhibit the improvements. Other factors such as the type of exercise and its frequency should also be considered as well.

Table 5. Comparison of changes in anthropometrics between control and intervention groups

Outcomes	Intervention (n=44)		p^1	Control (n=49)		p^2	p^3	p^4
	Baseline Mean (SD)	**Post-test** Mean (SD)		**Baseline** Mean (SD)	**Post-test** Mean (SD)			
Waist circumference (cm)	87.0 (6.04)	86.0 (6.36)	0.104	88.7 (8.14)	87.8 (7.51)	0.133	0.864	0.264
Hip (cm)	93.4 (4.33)	93.4 (4.49)	0.944	97.7 (6.78)	94.6 (6.89)	0.157	0.838	0.393
WHR	0.93 (0.05)	0.91 (0.04)	0.132	0.93 (0.05)	0.92 (0.04)	0.192	0.973	0.407
Weight (kg) [a]	60.6 (8.2)	58.5 (8.5)	0.001	61.4 (9.0)	62.4 (9.1)	0.473	0.776	0.039
BMI [a]	25.1 (2.1)	24.2 (2.3)	0.001	25.1 (2.3)	25.1 (2.4)	0.577	0.929	0.068

[1] Between post-test and baseline for the intervention group
[2] Between post-test and baseline for the control group
[3] Between control and intervention groups at baseline
[4] Between control and intervention groups at post-test
[a] Non-parametric tests applied due to skewed distributions

Table 5 shows the changes in anthropometrics after 6-month intervention in the two groups. At baseline, no significant improvements were observed for the control participants and between the control and intervention groups. At post-test, in the intervention group, reductions was observed in weight (-2.1kg, p=0.001) and BMI (-0.9kg/m^2, p=0.001) at six-month intervention. A significant difference was also found in weight (3.9kg, p=0.039) between the intervention and control groups at post-test. The role of PA and nutrition interventions in reducing the risks of T2D and CVDs has been well established [11]. Obesity raises the incidence of T2D to 20 times compared to normal-weight people [36] and is associated with a higher risk for mortality due to cardiovascular disease [37]. Therefore, weight reduction should be noted as a key target of lifestyle interventions for high-risk people. In the present study, weight and BMI decreased significantly in the intervention group, which was in line with other studies [38]. Since the control participants did not participate in walking groups, the outcome differences between the two groups indicate that the importance of PA levels together with the changes in dietary patterns might outweigh that of nutrition intervention only.

Health promotion is the process of enhancing people's awareness and self-control of their health [39]. It provides a wide range of social and environmental interventions. As discussed above, a health promotion program that targets lifestyle interventions effectively reduces the risk of T2D and CVDs, although maintaining the benefits in long-term frameworks might be challenging [12, 40]. Despite that, the importance of these interventions to prevent NCDs still remains evident and therefore calls for continuous developments and implementations of them [41]. The prevalence of NCDs in Vietnam, such as hypertension , diabetes, and CVDs [4], are increasing rapidly. This increase may be due to the significant economic growth in Vietnam, which is accompanied by the presence of aging populations and lifestyle changes that have shifted the health burden from non-communicable diseases to NCDs [42]. Therefore, interventions targeting lifestyle habits, if deployed on a large scale and are supposed for long-term changes, might positively reduce the burden of these diseases to prevent morbidity and mortality in high-risk groups of people.

CONCLUSION

The prescribed PA and nutrition intervention showed effectiveness in improving PA and dietary behaviors, reducing fasting glucose level, and some metabolic parameters among the pre-diabetic adutls in Vietnam.

ACKNOWLEDGMENTS: We would like to thank the residents of Hanam province who participated in the study. Thanks are also due to the Hanam Provincial Preventive Medicine Centre for participant recruitment and support during the trial.

CONFLICT OF INTEREST: None

FINANCIAL SUPPORT: The study was partly financially supported by Curtin University, Western Australia.

ETHICS STATEMENT: The research protocol was approved by the Curtin University Human Research Ethics Committee (approval number: HR139/2014).

REFERENCES

1. Kanjikar AP. On Anti-Diabetic Potential of Phyto-nanoparticles Comparison with Hormonal Therapy and Medicinal Plants. Int J Pharm Phytopharmacol Res. 2019;9(1):103-11.
2. Alzahrani S, Alosaimi ME, Oways FF, Hamdan AO, Suqati AT, Alhazmi FS, et al. Knowledge of Cardiovascular Diseases and Their Risk Factors among the Public in Saudi Arabia. Arch Pharm Pract. 2019;10(3):47-51.
3. WHO. Cardiovascular diseases (CVD) in Viet Nam. 2021 [cited 2021 25 May]; Available from: https://www.who.int/vietnam/health-topics/cardiovascular-diseases.
4. Ngoc NB, Lin ZL, Ahmed W. Diabetes: what challenges lie ahead for Vietnam?. Ann Glob Health. 2020;86(1).
5. Nguyen CT, Pham NM, Lee AH, Binns CW. Prevalence of and risk factors for type 2 diabetes mellitus in Vietnam: a systematic review. Asia Pac J Public Health. 2015;27(6):588-600.
6. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: a joint interim statement of the international diabetes federation task force on epidemiology and prevention; national heart, lung, and blood institute; American heart association; world heart federation; international atherosclerosis society; and international association for the study of obesity. Circulation. 2009;120(16):1640-5.
7. Dragsbæk K, Neergaard JS, Laursen JM, Hansen HB, Christiansen C, Beck-Nielsen H, et al. Metabolic syndrome and subsequent risk of type 2 diabetes and cardiovascular disease in elderly women: challenging the current definition. Medicine. 2016;95(36):e4806.
8. Saklayen MG. The global epidemic of the metabolic syndrome. Curr Hypertens Rep. 2018;20(2):12.

9. Binh TQ, Phuong PT, Nhung BT. Metabolic syndrome among a middle-aged population in the Red River Delta region of Vietnam. BMC Endocr Disord. 2014;14(1):1-9.
10. Zhang X, Devlin HM, Smith B, Imperatore G, Thomas W, Lobelo F, et al. Effect of lifestyle interventions on cardiovascular risk factors among adults without impaired glucose tolerance or diabetes: A systematic review and meta-analysis. PloS one. 2017;12(5):e0176436.
11. Rintamäki R, Rautio N, Peltonen M, Jokelainen J, Keinänen-Kiukaanniemi S, Oksa H, et al. Long-term outcomes of lifestyle intervention to prevent type 2 diabetes in people at high risk in primary health care. Prim Care Diabetes. 2021;15(3):444-50.
12. Jancey J, Lee AH, James AP, Howat P, Hills AP, Anderson AS, et al. Long-term sustainability of a physical activity and nutrition intervention for rural adults with or at risk of metabolic syndrome. Aust N Z J Public Health. 2020;44(5):421-6.
13. Lee AH, Jancey J, James AP, Howat P. Community-based physical activity and nutrition programme for adults with metabolic syndrome in Vietnam: study protocol for a cluster-randomised controlled trial. BMJ Open. 2016;6(6):e011532.
14. National Cholesterol Education Program (US). Expert Panel on Detection, Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. Circulation. 2002;106(25):3143-421.
15. Shamizadeh T, Jahangiry L, Sarbakhsh P, Ponnet K. Social cognitive theory-based intervention to promote physical activity among prediabetic rural people: a cluster randomized controlled trial. Trials. 2019;20(1):1-0.
16. Tran VD, Do VV, Pham NM, Nguyen CT, Xuong NT, Jancey J, et al. Validity of the international physical activity questionnaire–short form for application in Asian countries: a study in Vietnam. Evaluation & the health professions. 2020;43(2):105-9.
17. WHO, WHO STEPS Surveillance Manual. 2008: Geneve.
18. Kathariya G, Aggarwal J, Garg P, Singh S, Manzoor S. Is evaluation of non-HDL-C better than calculated LDL-C in CAD patients? MMIMSR experiences. Indian Heart J. 2020;72(3):189-91.
19. Burke L, Lee AH, Jancey J, Xiang L, Kerr DA, Howat PA, et al. Physical activity and nutrition behavioural outcomes of a home-based intervention program for seniors: a randomized controlled trial. Int J Behav Nutr Phys Act. 2013;10(1):1-8.
20. Hamilton MT, Healy GN, Dunstan DW, Zderic TW, Owen N. Too little exercise and too much sitting: inactivity physiology and the need for new recommendations on sedentary behavior. Curr Cardiovasc Risk Rep. 2008;2(4):292-8.
21. Muellmann S, Forberger S, Möllers T, Bröring E, Zeeb H, Pischke CR. Effectiveness of eHealth interventions for the promotion of physical activity in older adults: a systematic review protocol. Syst Rev. 2016;5:47.
22. Ribeiro EH, Garcia LM, Salvador EP, Costa EF, Andrade DR, Latorre MD, et al. Assessment of the effectiveness of physical activity interventions in the Brazilian Unified Health System. Rev Saude Publica. 2017;51:56.
23. WHO, Global recommendations on physical activity for health. 2010, WHO Press: Geneva.
24. Valenti G, Bonomi AG, Westerterp KR. Walking as a contributor to physical activity in healthy older adults: 2 week longitudinal study using accelerometry and the doubly labeled water method. JMIR Mhealth Uhealth. 2016;4(2):e5445.
25. National Institute of Nutrition of Vietnam. Food-based dietary guildelines - Vietnam. 2021 [cited 2021 03 May]; Available from: http://viendinhduong.vn/news/en/714/123/food-based-dietary-guidelines---viet-nam.aspx.
26. Julibert A, del Mar Bibiloni M, Tur JA. Dietary fat intake and metabolic syndrome in adults: a systematic review. Nutr Metab Cardiovasc Dis. 2019;29(9):887-905.
27. Sarebanhassanabadi M, Mirhosseini SJ, Mirzaei M, Namayandeh SM, Soltani MH, Pakseresht M, et al. Effect of dietary habits on the risk of metabolic syndrome: Yazd Healthy Heart Project. Public Health Nutr. 2018;21(6):1139-46.
28. Wagner MG, Rhee Y, Honrath K, Salafia EH, Terbizan D. Nutrition education effective in increasing fruit and vegetable consumption among overweight and obese adults. Appetite. 2016;100:94-101.

29. de Vreede PL, van Meeteren NL, Samson MM, Wittink HM, Duursma SA, Verhaar HJ. The effect of functional tasks exercise and resistance exercise on health-related quality of life and physical activity. Gerontology. 2007;53(1):12-20.
30. Oldroyd JC, Unwin NC, White M, Mathers JC, Alberti KG. Randomised controlled trial evaluating lifestyle interventions in people with impaired glucose tolerance. Diabetes Res Clin Pract. 2006;72(2):117-27.
31. Jesmin S, Sohael F, Rahman MA, Maqbool A, Islam MM, Shima T, et al. Short-term lifestyle intervention program through daily walking improves circulatory low HDL level in rural Bangladeshi women. J Phys Fit Sports Med. 2020;9(4):181-90.
32. Campbell MD, Sathish T, Zimmet PZ, Thankappan KR, Oldenburg B, Owens DR, et al. Benefit of lifestyle-based T2DM prevention is influenced by prediabetes phenotype. Nat Rev Endocrinol. 2020;16(7):395-400.
33. Guess ND. Dietary interventions for the prevention of type 2 diabetes in high-risk groups: current state of evidence and future research needs. Nutrients. 2018;10(9):1245.
34. Bajer B, Rádiková Ž, Havranová A, Žitňanová I, Vlček M, Imrich R, et al. Effect of 8-weeks intensive lifestyle intervention on LDL and HDL subfractions. Obes Res Clin Pract. 2019;13(6):586-93.
35. Lin WY. A large-scale observational study linking various kinds of physical exercise to lipoprotein-lipid profile. J Int Soc Sports Nutr. 2021;18(1):35.
36. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. BMC Public Health. 2009;9(1):1-20.
37. Afshin A, Forouzanfar MH, Reitsma, MB, Sur P, Estep K, Lee A, et al. Health Effects of Overweight and Obesity in 195 Countries over 25 Years. N Engl J Med. 2017;377(1):3-27.
38. Webb VL, Wadden TA. Intensive lifestyle intervention for obesity: principles, practices, and results. Gastroenterology. 2017;152(7):1752-64.
39. Ngigi S, Busolo DN. Behaviour change communication in health promotion: Appropriate practices and promising approaches. Int J Innov Res Dev. 2018;7(9):84-93.
40. Saboya PP, Bodanese LC, Zimmermann PR, Gustavo AD, Macagnan FE, Feoli AP, et al. Lifestyle intervention on metabolic syndrome and its impact on quality of life: a randomized controlled trial. Arq Bras Cardiol. 2016;108(1):60-9.
41. Arena R, Guazzi M, Lianov L, Whitsel L, Berra K, Lavie CJ, et al. Healthy lifestyle interventions to combat noncommunicable disease—a novel nonhierarchical connectivity model for key stakeholders: a policy statement from the American Heart Association, European Society of Cardiology, European Association for Cardiovascular Prevention and Rehabilitation, and American College of Preventive Medicine. Eur Heart J. 2015;36(31):2097-109.
42. Nguyen TT, Trevisan M. Vietnam a country in transition: health challenges. BMJ Nutr Prev Health. 2020;3(1):60.