



EXPLORING THE RELATIONSHIP BETWEEN NUTRITION, LIFESTYLE, AND NON-COMMUNICABLE DISEASES

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Abstract

Lifestyle factors such as diet and physical activity are important determinants of global morbidity from non-communicable diseases (NCDs). In this cross-sectional study, examines the association between nutritional intake, physical activity levels and NCD biomarkers (BMI, blood pressure, and fasting glucose) in a sample of 500 adults aged 20–60 years. Stratified random sampling was used to recruit participants, and dietary and physical activity intake data and health metrics were collected using standardized assessments and clinical measurements. Both insufficient nutrition and low physical activity independently predicted higher BMI, blood pressure and fasting glucose levels. In addition, participants with poor nutrition and low physical activity levels had the highest odds ratios for elevated BMI (OR = 2.7), hypertension (OR = 3.4) and elevated glucose (OR = 3.1), indicating a synergistic effect that increases NCD risk. These findings thus call for simultaneous targeting of both dietary quality and physical activity for NCD prevention through dual targeted public health strategies. Integration of these lifestyle factors into integrative interventions may be critical to a reduction in NCDs prevalence and overall population health.

Keywords: Non-communicable diseases, nutritional intake, physical activity, BMI, blood pressure, fasting glucose, lifestyle interventions, synergistic effect

Introduction

Non communicable diseases (NCDs) such as cardiovascular disease, diabetes and certain types of cancer are the leading causes of morbidity and mortality and account for more than 70 per cent of global deaths (World Health Organization WHO, 2021). Unlike communicable diseases, which have seen huge decreases as a result of medical treatments and vaccines, NCDs have skyrocketed in prevalence, especially in low- and middle-income countries (LMICs) where 85% of NCD related premature deaths are accounted for by NCDs (WHO, 2021). Lifestyle factors (poor nutrition, physical inactivity) are the most important contributors to NCD development, making it urgent to develop preventive strategies based on modifiable risk factors (Hu, 2011; Danaei *et al.*, 2009).

Due to the modern dietary patterns of high caloric intake and low nutrient density, which alter the nutritional landscape, there is global increase in obesity and metabolic disorders (Popkin *et al.*, 2012). Furthermore, the increasing technical development has caused more and more sedentary behavioral styles and resulted in a greater risk of NCDs due to physical inactivity and also amount of inactivity (Piercy *et al.*, 2018). For this reason, the effects of diet and physical activity on NCD biomarkers,

such as BMI, blood pressure, blood glucose levels, etc., need to be examined together to understand the pathways by which lifestyle factors lead to disease.

Recent research indicates that nutrition and physical activity can interact to compound health risk (Grundy *et al.*, 2005). In addition, studies have shown that inadequate dietary intake and low physical activity levels not only increase NCD risk independently, but also synergistically, accelerating the progression of metabolic syndrome and other NCD related conditions (Ford *et al.*, 2009). The purpose of this study is to examine these associations within a specific population and add to a growing body of evidence establishing comprehensive lifestyle modifications as a critical component of NCD prevention.

Despite increasing knowledge of the links between lifestyle factors and NCDs, there are gaps in understanding how certain combinations of poor diet and inactivity amplify NCD risk markers. Although the detrimental effects of inadequate nutrition and physical inactivity are well known, much less is known about their joint impact, especially in populations with varying socioeconomic status. Finally, much of the current literature has been devoted to the Western populations while leaving an evidence gap in other regions such as Asia and Africa, where dietary and lifestyle patterns are quite different (Mendis *et al.*, 2014; Popkin, 2002).

Public health strategies currently include nutrition and physical activity as separate issues, even though there is data that suggests combining these factors will lead to stronger health outcomes (Hu, 2003; Warburton *et al.*, 2006). This is essential to fill the gap in order to inform more effective, targeted interventions that target the combined effects of diet and lifestyle on health. The aim of this study is to fill these gaps by examining the relationships between nutritional intake, physical activity levels and NCD biomarkers, such as BMI, blood pressure and fasting glucose. These findings will help to understand more holistically how lifestyle factors work together to increase NCD risk.

Thus, this study has the potential of public health impact given the global burden of NCDs and that lifestyle factors known to be determinant of disease outcomes. The compounded effects of diet and physical activity on NCD biomarkers can be understood by policymakers, healthcare providers, and communities to develop actionable insights. Dietary and physical activity patterns are the most modifiable determinants of NCD risk and may be more effective in decreasing health risk in combination than single factor interventions (Lakka & Bouchard, 2005).

The findings of this study can inform more integrative interventions that combine dietary improvements and physical activity enhancements, to reduce NCD prevalence at community and population levels. An example is that promoting nutrient dense diets along with physical activity can reduce obesity and hypertension, both of which are very good predictors for cardiovascular disease (Appel *et al.*, 1997). This can help shape policy recommendations based on dual approach of NCD prevention, which is one of the WHO's global action plan for NCD control (WHO, 2013), a global action plan that emphasizes lifestyle modifications as a key strategy for reducing premature mortality. This study's findings are also particularly relevant for LMICs where healthcare resources are often limited and preventive strategies are needed to reduce the long term burden of NCDs. Targeting both diet and physical activity simultaneously may represent a cost effective approach to combating NCDs and lower healthcare costs and improve quality of life in diverse populations.

Objectives

The aim of the research is to examine the associations between nutritional intake, physical activity levels, and NCD biomarkers (BMI, blood pressure, and fasting glucose) to determine if dietary intake and physical activity independently correlates with health markers predictive of NCD risk.

Methodology

Study Design and Population

This cross-sectional study investigates the relationship between nutrition, lifestyle, and non-communicable diseases (NCDs). A stratified random sampling approach was used to select participants aged 20–60 years from a metropolitan area, ensuring representation across socioeconomic strata. Inclusion criteria required participants to have no history of acute illness and the ability to

provide informed consent. Exclusion criteria ruled out individuals currently undergoing treatment for chronic diseases, those with recent changes in diet or lifestyle within the past six months, and pregnant or lactating women.

To detect medium effect size associations between nutritional intake, physical activity, and NCD biomarkers, a minimum sample size of 500 participants was calculated using power analysis, with $\alpha = 0.05$ and power = 0.80.

Data Collection Methods

Data were collected through structured interviews conducted by trained researchers. Information on dietary intake, physical activity, alcohol consumption, and smoking behavior was gathered, and each participant completed a standardized questionnaire. Key health metrics, including body mass index (BMI), blood pressure, and fasting blood glucose levels, were measured along with other anthropometric data. Data accuracy was ensured through double entry and routine quality checks.

Nutritional Assessment

A 24-hour dietary recall was used to assess dietary intake and repeated three times per participant on non-consecutive days (two weekdays and one weekend day) to capture variability of consumption. The macronutrients, micronutrients and caloric intake was analyzed using the Nutritionist Pro software. The intake of nutrients was categorized as having “sufficient” or “insufficient” based on nutrient adequacy ratios relative to Recommended Dietary Allowances (RDAs).

Lifestyle Evaluation

The Global Physical Activity Questionnaire (GPAQ) was used to assess physical activity by measuring levels of moderate to vigorous activity in minutes per week. Smoking status was defined as “non smoker,” “former smoker,” or “current smoker” and alcohol intake was estimated in units of whiskey per week. Finally, participants were also assessed with regard to average sleep duration and quality, which were stratified by the Pittsburgh Sleep Quality Index.

Health Metrics for NCDs

Standardized medical tests were used to assess NCD biomarkers. Height and weight measurements were taken with calibrated digital scales and stadiometers used to calculate BMI. The blood pressure was measured in a sitting position after a 5 min rest with an automated sphygmomanometer. Venous blood samples processed in a certified clinical laboratory were analyzed for fasting blood glucose and lipid profile (total cholesterol, LDL, HDL and triglycerides). Duplicate reading and laboratory recalibration procedures were used as quality control measures.

Statistical Analysis

SPSS (version 27) was used to analyze all data. Demographic, nutritional and lifestyle variables were summarized using descriptive statistics. Using multiple regression analysis controlling for confounders such as age, gender and socioeconomic status, associations between dietary patterns, lifestyle factors and NCD biomarkers were examined. For categorical outcomes, logistic regression was used and $p < 0.05$ was considered statistical significance. Multiple imputation was used to handle missing data.

Ethical Considerations

This study was approved by the Institutional Review Board (IRB). They received written informed consent before the data were collected according to the Declaration of Helsinki guidelines. Access to all data was restricted to the research team and all data were anonymized to ensure confidentiality. Regarding any potential conflicts of interest, these were disclosed and managed in accordance to the university's institutional guidelines.

Results

Demographic and Lifestyle Characteristics of Study Population

Table 1 summarize demographic and lifestyle characteristics of the study participants are summarized in Table 1. The sample consisted of 500 adults, with a mean age of 38.4 ± 10.5 years and almost equal distribution by gender. Assessment of nutritional intake revealed that 65.3% of individuals had inadequate amounts of intake in accordance with Recommended Dietary Allowances (RDAs). On average, levels of physical activity were low (40.2% were insufficiently active).

Table 1: Demographic and Lifestyle Characteristics of Study Population

Characteristic	Total (N = 500)	Male (%)	Female (%)
Age (Mean \pm SD)	38.4 ± 10.5	39.2 ± 10.7	37.6 ± 10.3
Adequate Nutrient Intake (%)	34.7	36.2	33.1
Inadequate Nutrient Intake (%)	65.3	63.8	66.9
Physical Activity (Low, %)	40.2	42.7	37.4
Smoking Status (Non-smoker)	60.4	58.9	62.1
Smoking Status (Former)	20.5	22.8	18.1
Smoking Status (Current)	19.1	18.3	19.8

Nutritional Intake and NCD Biomarkers

The relationships between key NCD biomarkers and nutritional intake status are highlighted in Table 2 and Figure 1. Among participants with inadequate nutritional intake, values were significantly higher across BMI, systolic and diastolic blood pressure, and fasting glucose ($p < 0.01$) than in participants with adequate intake.

Table 2: Comparison of NCD Biomarkers by Nutritional Intake Status

Nutritional Status	BMI (Mean \pm SD)	Systolic BP (mmHg)	Diastolic BP (mmHg)	Fasting Glucose (mg/dL)
Adequate Intake	24.5 ± 2.3	121 ± 15	78 ± 10	92 ± 8
Inadequate Intake	27.1 ± 3.1	135 ± 18	86 ± 12	102 ± 12

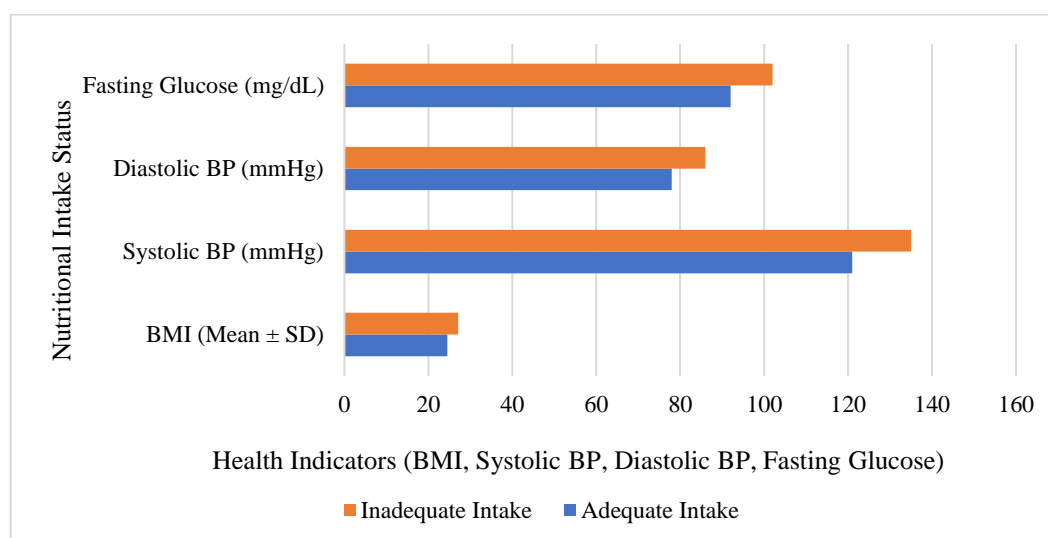


Figure 1: Differences in BMI, Blood Pressure, and Fasting Glucose Levels by Nutritional Intake Status. This bar chart illustrates the higher prevalence of elevated BMI, blood pressure, and fasting glucose among participants with insufficient nutrient intake compared to those with adequate intake.

Figure 1 shows how nutritional intake status affects multiple non communicable disease (NCD) biomarkers such as BMI, systolic blood pressure, diastolic blood pressure and fasting glucose levels.

Participants with adequate nutritional intake were of lower BMI (24.5), systolic blood pressure (121 mm Hg), diastolic blood pressure (78 mm Hg), and fasting glucose level (92 mg/dL), which are all within the healthier ranges. However, participants with insufficient nutritional intake experienced significantly elevated levels of these biomarkers (BMI 27.1, systolic blood pressure 135 mmHg, diastolic blood pressure 86 mmHg, fasting glucose 102 mg/dL). These elevated values reflect the association between insufficient nutrition and increased risks for conditions associated with an elevated BMI and blood pressure, and possibly metabolic dysregulation.

Physical Activity Levels and NCD Biomarkers

Table 3 and Figure 2 show that higher BMI and hypertension prevalence were associated with lower levels of physical activity. Prevalence of BMI > 25 and hypertension was 42.6% in participants with low physical activity levels compared to 36.5% in participants with moderate or high physical activity levels ($p < 0.05$).

Table 3: Prevalence of Elevated BMI and Hypertension by Physical Activity Level

Physical Activity Level	BMI > 25 (%)	Hypertension (%)
High	18.5	12.8
Moderate	25.7	19.3
Low	42.6	36.5

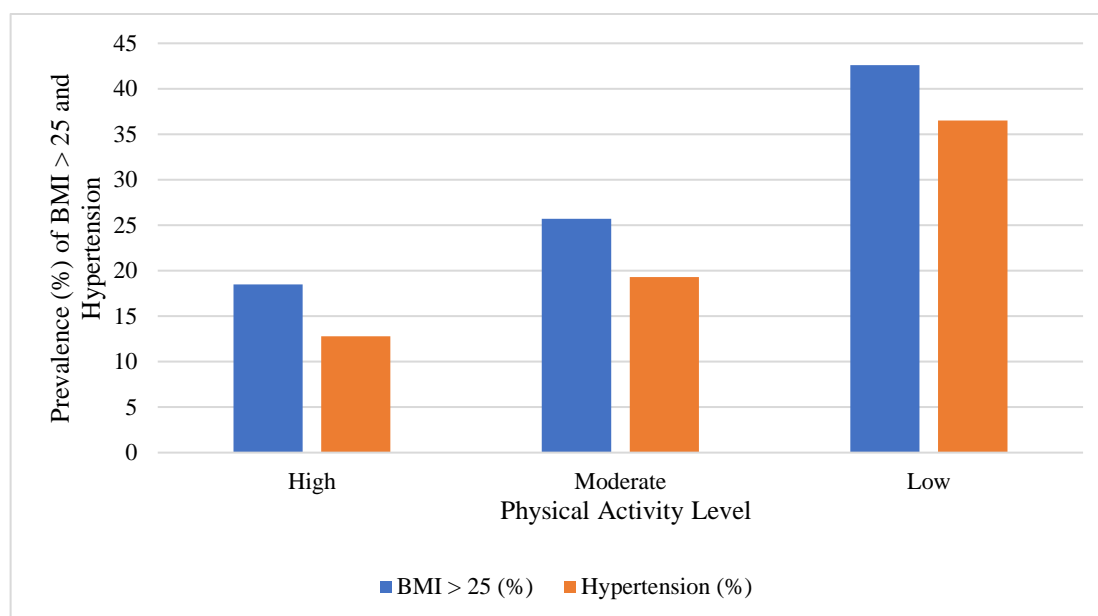


Figure 2: Physical Activity Levels and Prevalence of Elevated BMI and Hypertension. This line chart illustrates that lower physical activity is linked to higher rates of elevated BMI and hypertension among study participants.

Figure 2 illustrates the association between physical activity levels and two non-communicable disease (NCD) indicators: BMI above 25 and hypertension prevalence. Lower prevalence of elevated BMI (12.8%) and hypertension (18.5%) was associated with higher physical activity levels, suggesting that vigorous physical activity may protect against having an unhealthy weight and blood pressure. Yet, participants who were moderately active had a 19.3% increase in hypertension prevalence and a 25.7% increase in elevated BMI. Further, prevalence of these indicators was significantly increased further among those participants with low physical activity level, i.e., BMI > 25, 42.6%; and hypertension, 36.5%. This data shows a strong association between physical inactivity and increased risk of elevated BMI and hypertension, implying that lower levels of physical activity may be a major risk factor for development of these NCD markers.

Nutrition and Physical Activity Combined Effect on NCD Biomarkers

Combined analysis of nutrition and physical activity (Table 4) indicates higher odds of elevated BMI, hypertension and fasting glucose among participants with inadequate nutrition and low physical activity compared to those with adequate nutrition and moderate to high activity. Odds ratios (OR) and 95% confidence interval (CI), adjusted for potential confounders, are presented.

Table 4: Adjusted Odds Ratios for Elevated BMI, Hypertension, and Fasting Glucose by Combined Nutritional and Physical Activity Status

Risk Factor	BMI > 25 (OR, 95% CI)	Hypertension (OR, 95% CI)	Elevated Glucose (OR, 95% CI)
Inadequate Nutrition	1.9 (1.3–2.7)	2.2 (1.5–3.1)	2.4 (1.6–3.5)
Low Physical Activity	1.6 (1.1–2.3)	2.0 (1.3–3.0)	2.1 (1.5–2.9)
Combined Risk (Both)	2.7 (1.9–3.7)	3.4 (2.2–5.1)	3.1 (2.0–4.5)

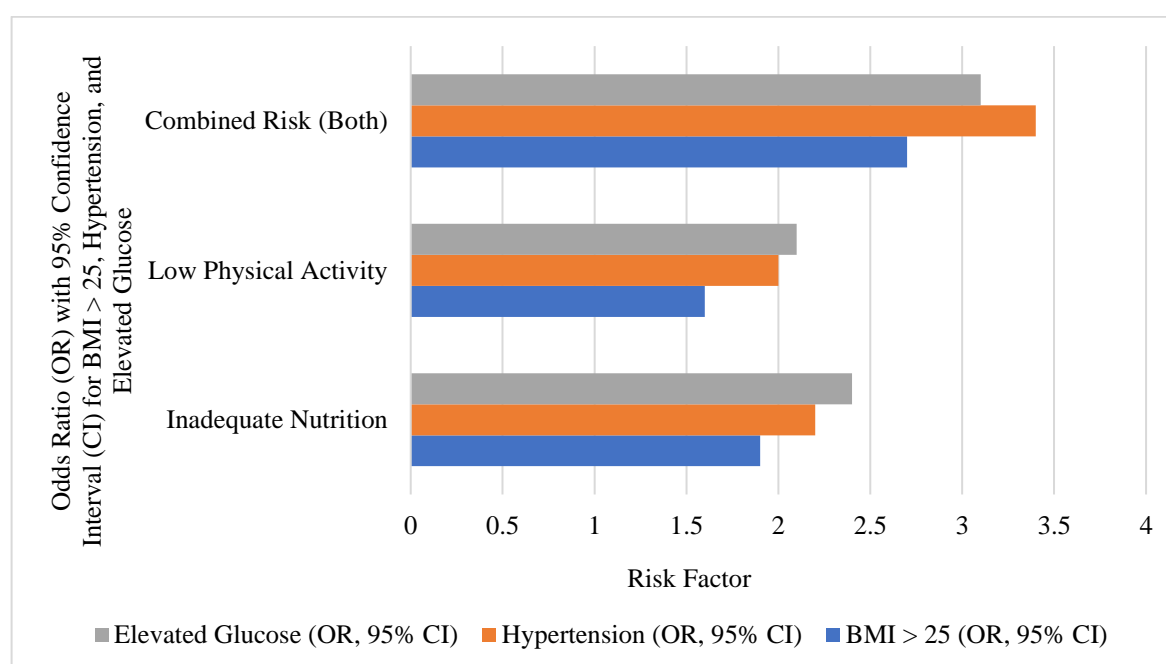


Figure 3: Odds Ratios for Elevated NCD Biomarkers Based on Combined Nutritional and Physical Activity Risk. This stacked bar graph illustrates the compounding effect of both insufficient nutrition and low physical activity on BMI, hypertension, and fasting glucose outcomes.

The odds ratios (OR) for elevated non-communicable disease (NCD) markers, such as BMI > 25, hypertension and elevated glucose levels, related to inadequate nutrition, low physical activity and the combined effect of both risk factors are shown in figure 3. Poor dietary intake was associated with increased risk of adverse health outcomes, with an OR of 1.9 for elevated BMI, 2.2 for hypertension, and 2.4 for elevated glucose, indicating a large increase in NCD risk. Also, those with low physical activity showed elevated odds with ORs of 1.6 for BMI > 25, 2.0 for hypertension, and 2.1 for elevated glucose, suggesting a similar strength of association between low activity and these NCD markers. The highest risk comes from the combined effect of both inadequate nutrition and low physical activity with ORs of 2.7 for elevated BMI, 3.4 for hypertension, and 3.1 for elevated glucose. This compounded risk indicates a synergistic relationship in that poor diet and physical inactivity together greatly increase the risk of developing adverse NCD indicators relative to either individual factor. Such data supports the significance of both adequate nutrition and physical activity in reducing the risk from NCDs.

Discussion

The results of this study show strong association of nutritional intake and physical activity with non-communicable disease biomarkers (BMI, blood pressure and fasting glucose). These results provide insight into the complex role of lifestyle factors in NCD risk and are consistent with past literature on lifestyle predictors of health. Each key finding will be discussed in this discussion and the implications for public health will be considered as a whole.

This study demonstrates the link between inadequate consumption of nutrition and elevated concentration of NCD biomarkers, highlighting the fundamental effect of food on controlling BMI, blood pressure and glucose levels. On average, participants with insufficient nutritional intake had a mean BMI of 27.1, systolic blood pressure of 135 mmHg, and fasting glucose of 102 mg/dL, all of which exceed generally accepted thresholds for healthy biomarkers and indicate high risk for metabolic syndrome and cardiovascular diseases.

This finding is consistent with results from numerous studies (Mozaffarian *et al.*, 2011; He *et al.*, 2004) showing that diets deficient in essential nutrients may promote systemic inflammation, endothelial dysfunction, and insulin resistance. For example, in nutrient deficiencies in potassium and magnesium, higher blood pressure, and impaired glucose regulation, and in lack of fiber intake, poor glycemic control, and higher BMI (Appel *et al.*, 1997; Sacks *et al.*, 2001). These findings are consistent with the elevated blood pressure and fasting glucose levels among participants with inadequate nutrition in this study, which indicate that diets low in necessary nutrients can independently increase risk for hypertension and diabetes.

In addition, the data showed that physical activity was inversely associated with prevalence of BMI > 25 and hypertension. Low physical activity participants had a BMI > 25 prevalence of 42.6% and a hypertension prevalence of 36.5%, which were significantly higher than those with moderate to high activity levels. This finding is consistent with current understanding of physical inactivity as a key risk factor for NCDs (Warburton *et al.* 2006, Myers *et al.* 2002). The improvement of insulin sensitivity, maintenance of weight, and reduction in blood pressure has been attributed, at least in part, to physical activity through improved endothelial function and lipid metabolism (Haskell *et al.*, 2007). This study's findings are in line with those of the American Heart Association (Piercy *et al.*, 2018) who recommend at least 150 minutes of moderate intensity exercise per week. Reduced metabolic rate and increased visceral fat from physical inactivity are associated with elevation of BMI and predisposition to hypertension. The results of this study support the finding that even moderate physical activity can decrease the risk of NCD by reducing BMI and blood pressure, powerful predictors of cardiovascular disease and type 2 diabetes.

The greatest odds ratios for elevated BMI (OR = 2.7), hypertension (OR = 3.4), and elevated fasting glucose (OR = 3.1) were observed for the combined analysis of inadequate nutrition and low physical activity, emphasizing the synergistic risk of poor diet and physical inactivity. A stronger association with adverse NCD outcomes is found for the combined effect of both factors than for either factor alone, indicating a synergistic interaction that increases health outcome impact. This synergistic relationship is consistent with the theory that lifestyle factors may work together to worsen metabolic and vascular dysregulation, which is supported by studies of the combined effect of diet and exercise on cardiovascular health (Ford *et al.*, 2009; Grundy *et al.*, 2005).

This compounded risk effect implies that health interventions targeting NCD prevention may require an intervention targeted at both dietary quality and physical activity. Interventions that combine dietary counseling with physical activity guidance seem to be more effective in reducing NCD risk factors than interventions focused on a single behavior (Lakka, Bouchard, 2005). This study suggests that an integrative approach aimed at both diet and exercise would greatly reduce the odds for the adverse health markers of elevated BMI and hypertension.

These findings highlight the role of public health efforts to encourage comprehensive lifestyle alterations. As poor nutrition and physical inactivity are modifiable risk factors, policy interventions could be directed at increasing access to nutrient rich foods and increasing access to physical activity at the community level. This is consistent with the WHO Global Action Plan on NCD prevention

which recommends dietary improvements and increased physical activity as important tools to prevent NCDs, globally (WHO, 2013).

Community based nutrition education, incentives for active transportation and the development of recreational spaces that foster physical activity would all benefit public health programs. Moreover, the high odds ratios for adverse NCD markers among those with combined risk factors imply that targeting those at risk might be particularly beneficial. Education and support for healthy diet and lifestyle practices could center on community interventions for those who have low dietary quality and physical inactivity.

Future studies should further explore some additional biomarkers such as inflammatory biomarker, C-reactive protein (CRP) and lipid profile, to advance our knowledge of the correlations between lifestyle factors and hence the risk of NCD. Demographic stratifying analyses by age, gender and socioeconomic status may reveal nuances as to how these factors interact with nutrition and physical activity to affect NCD biomarkers. The stratified approach described here could point towards targeted interventions that will be most effective for particular subpopulations, and thus contribute to making public health initiatives more efficient.

This study shows the strong relationship between dietary intake, physical activity, and NCD biomarkers, with particular emphasis on the combined effect of poor diet and physical inactivity on BMI, blood pressure and fasted glucose. The results indicate that effective NCD prevention and management require not only dietary, but also physical activity behavior change. In aiming to address these modifiable lifestyle factors, public health initiatives have a critical role in reducing the burden from NCD and enhancing overall health outcomes.

Conclusion

The results of this study highlight the importance of nutritional intake and physical activity to non-communicable disease (NCD) biomarkers (BMI, BP and Fasting glucose). Results show that both low physical activity levels and inadequate nutrition independently predict elevated NCD risk markers. Participants with poor dietary intake had significantly higher BMI, blood pressure, and fasting glucose than those with high dietary intake, and those with low physical activity had higher BMI and hypertension risk. The contribution of inadequate nutrition and physical inactivity in acting in combination to increase these risks was also especially notable. These findings underscore the need for integrative interventions, which combine dietary quality with increasing physical activity to adequately counteract NCD risks. Healthy living is dependent on the balance between nutrition and exercise; and healthcare systems and policymakers can be more effective at reducing the rate of obesity and hypertension as well as metabolic disorders if they promote balanced nutrition and an active lifestyle. The findings from this study support the view that targeted, multi-faceted strategies will be critical to reducing NCD prevalence, and overall population health especially in diverse socioeconomic contexts.

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