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# Factors associated with the longitudinal maintenance of active life among Brazilian adults (CUME Study)

## Fatores associados à manutenção longitudinal da vida ativa entre adultos brasileiros (Estudo CUME)

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## ABSTRACT

Introduction: The benefits of regular physical exercise for the prevention and treatment of chronic diseases have been well documented; and physically active individuals tend to adopt other positive health habits. Objective: To evaluate the longitudinal maintenance of active life among participants from the Cohort of Universities of Minas Gerais (CUME)/Brazil and associated factors. Methods: This is a prospective study, with data collected in 2016, 2018, and 2020. Sociodemographic, dietary, lifestyle, and physical activity variables were assessed. Poisson regression analysis was used for data analysis. Results: A total of 2,546 volunteers participated in the study. During this period, 40% of participants remained active from baseline to the first wave, 30% from the second to the third wave, and 29% throughout follow-up. For data analysis, two models were tested, one including ultra-processed foods and the other including natural and minimally processed foods. In the model adjusted with ultra-processed foods, the participants who were least likely to remain physically active were those aged between 30 and 50 years (PR = 0.94; p-value = 0.005), smokers (PR = 0.90; p-value = 0.003), and those who consumed higher proportions of energy from ultra-processed foods (2nd tertile RP = 0.94, p-value = 0.007 and 3rd tertile RP = 0.97, p-value <0.001); while consuming alcoholic beverages was protective (PR = 1.09; p-value <0.001). A similar result was observed in the model with the inclusion of natural and minimally processed foods; however, a higher proportion of energy from minimally processed foods increased the likelihood of maintaining an active lifestyle (2nd tertile PR = 1.07, p-value = 0.004 and 3rd tertile PR = 1.15, p-value p<0.001). Conclusions: A reasonable number of cohort participants remained physically active. However, the results reinforce the need for health education actions, with an emphasis on physical activity and adequate nutrition for a better quality of life, especially in the group with lower adherence to this practice, that is, those between 30 and 50 years old, smokers, and those who consumed higher proportions of energy from ultra-processed foods.

**Keywords**: Cohort studies; Adult; Physical activity; NOVA Food Classification.

## RESUMO

*Introdução: Os benefícios da prática regular de exercícios físicos para prevenção e tratamento de doenças crônicas são bem documentados; e indivíduos fisicamente ativos tendem a adotar outros hábitos positivos de saúde. Objetivo: Avaliar a manutenção longitudinal da vida ativa entre participantes de uma Coorte de Universidades de Minas Gerais (CUME)/Brasil e fatores associados. Métodos: Trata-se de um estudo prospectivo com informações obtidas nos anos de 2016, 2018 e 2020. Foram avaliadas variáveis sociodemográficas, dietéticas, de estilo de vida e prática de atividades físicas. A análise de regressão de Poisson foi utilizada para análise dos dados. Resultados: Participaram do estudo 2.546 voluntários. Nesse período, 40% dos participantes permaneceram ativos da linha de base até a primeira onda, 30% da segunda até a terceira onda e 29% em todo o follow-up. Para análise dos dados foram testados dois modelos, um com inclusão de alimentos ultraprocessados e outro com alimentos in natura e minimamente processados. No modelo ajustado com alimentos ultraprocessados os participantes que apresentaram menor probabilidade de permanecerem fisicamente ativos foram os de idade entre 30 e 50 anos (RP = 0,94; p-valor = 0,005), os fumantes (RP = 0,90; p-valor = 0,003), e os que consumiam maiores proporções de energia de alimentos ultraprocessados (2º tercil RP = 0,94, p-valor = 0,007 e 3º tercil RP = 0,97, p-valor <0,001); enquanto consumir bebida alcóolica foi protetivo (RP = 1,09; p-valor <0,001). Resultado semelhante foi observado no modelo com a inclusão dos alimentos in natura e minimamente processados, contudo, maior proporção de energia desse grupo de alimentos aumentou a probabilidade da manutenção de vida ativa (2º tercil RP = 1,07, p-valor = 0,004 e 3º tercil RP = 1,15, p-valor = p<0,001). Conclusões: Um número razoável de participantes da coorte permaneceu fisicamente ativo. No entanto, os resultados reforçam a necessidade de ações em educação em saúde, com ênfase na prática de atividade física e alimentação adequada para melhor qualidade de vida, especialmente no grupo com menor adesão à esta prática, ou seja, os com idade entre 30 e 50 anos, fumantes e aqueles que consumiam maiores proporções de energia de alimentos ultraprocessados.*

**Palavras-chave**: *Estudos de coorte; Adulto; Exercício físico; Classificação NOVA de Alimentos.*

## Introduction

Physical inactivity is a significant public health concern, and poor adherence to activity programs is often reported. Physical activity has become a standard practice in clinical care because it offers numerous benefits in both pathological and non-pathological populations[1]. In this regard, including physical activity programs into treatment plans is now an essential tool for most healthcare providers[2]. Physical activity can reduce the risk of premature mortality by 20% to 30% in individuals with more than 26 types of chronic conditions[3].

Physical activity has often been used as a synonym for physical exercise; however, they are not the same. Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure. The energy expenditure can be measured in kilocalories. Physical activity in daily life can be categorized into occupational, sports, conditioning, household, or other activities. Physical exercise, on the other hand, is a subset of physical activity that is a planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness[4].

Physical activity is recommended for individuals at various life stages; there is evidence of the benefits of physical activity for children and adolescents (5 to under 18 years of age) on prosocial behavior (e.g., conduct problems, peer relations, social inclusion) and sleep duration and quality. Among adults, improvements in sleep duration and quality, lower incidence of hypertension, and health-related quality of life have been identified. Among the elderly, has a positive effect on psychosocial outcomes (e.g., social isolation, social participation)[5]. Quality of life plays a moderating role in the relationship between physical exercise and various aspects, such as psychological resilience, mental health and health-related behaviors[6].

The World Health Organization document "Global Action Plan on Physical Activity 2018–2030: More Active People for a Healthier World"[7] highlights the need for a global plan to prevent a sedentary lifestyle. For this, a collective and coordinated response from all relevant stakeholders at all levels is needed in the different contexts where people live, work, and play. Therefore, to ensure a more active future, it is necessary to implement proactive infrastructure construction policies, integrate transport policies and urban planning, improve pedestrian routes and cycle paths, and reinforce road safety[7].

Despite the benefits of physical exercise/activity for preventing and controlling chronic diseases, few studies have attempted to assess whether people with noncommunicable diseases (NCDs) are more predisposed to maintaining physical activity. In this context, this study aimed to evaluate the variables associated with the longitudinal maintenance of an active lifestyle among participants in a Cohort of Universities in Minas Gerais.

## Methods

### Study design and participants

The Cohort of Universities of Minas Gerais (CUME) is a longitudinal observational study of the open cohort type, carried out since 2016 with graduates and undergraduates from seven public and higher education institutions in Minas Gerais, Brazil. This study aims to evaluate the impact of Brazilian dietary patterns and nutrition transition on NCDs. The recruitment of participants is permanent, allowing continuous sample size growth with each follow-up wave, which occurs every 2 years. The project design, dissemination strategies, and profiles of the first baseline participants were detailed in a previous publication[8].

Notably, for the participants recruited at baseline, the universities participating in the study sent four standardized e-mails, with an interval of seven days, to their graduate and undergraduate students, inviting them to participate. In subsequent waves, a professional responsible for receiving the responses and assembling the database is the one who sends the e-mails to the participants. It stands out that it is impossible to determine the number of people who receive the e-mail since the e-mails sent were those from the university's database when the eligible participants were students, and many change their email addresses throughout the year. Therefore, it is impossible to determine the proportion of students who received invitations and agreed to participate in the study. However, the response rate in online surveys via e-mail is expected to be approximately 6%[9].

Therefore, the participants in this study were those who remained in the three waves of cohort follow-up (2016, 2018, and 2020), resulting in a total of 3,134 participants. Among them, we excluded those with the following characteristics: 1) did not report physical activity in the second or third wave (n = 244); 2) reported extreme energy consumption, i.e., less than 600 kcal/day or more than 6000 kcal/day[10] (n = 2);

3) reported other nationalities (n = 2); 4) lived outside Brazil in the year before the research (n = 111); and 4) were pregnant or became pregnant in the year before the survey (n = 229). Eligible participants for this study were those who responded to the baseline (Q_0) and follow-up (Q_2 and Q_4) questionnaires, reported exercising, and provided information on sociodemographics, lifestyle, clinical conditions, and dietary intake.

The study was conducted in accordance with the guidelines of the Declaration of Helsinki and approved by the ethics committees of the universities involved 596.741-0/2013 (*Universidade Federal de Viçosa*), 2.491.366/15 (*Universidade Federal de Minas Gerais*), 2.565.240 (*Universidade Federal de Ouro Preto*), 2.615.738 (*Universidade Federal de Juiz de Fora*), 2676682 (*Universidade Federal de Lavras*), 3.989.443 (*Universidade Federal dos Vales do Jequitinhonha e Mucuri*) and 4.051.344 (*Universidade Federal de Alfenas*).

## Study protocol and data collection

As mentioned previously, invitations were sent via electronic mail to all graduates and undergraduates of the participating universities in the study during the aforementioned periods to collect the data. The e-mails used were those contained in the databases of the participants' universities. Those who agreed to participate in the study received an email with a link to access a questionnaire consisting of two blocks of questions. The first block included questions about sociodemographic and economic characteristics, lifestyle (cigarette smoking, alcohol consumption, and physical activity, with information on type of activity, frequency, and time spent), reported individual and family morbidity, use of medications, personal history of clinical and biochemical examinations of the last two years, and anthropometric and food consumption data (consumption frequency questionnaire) (https://www.projetocume.com.br/questionario).

The second block of the baseline questionnaire was presented to the participants as a Food Frequency Questionnaire (FFQ), organized into the following food groups: dairy products, meat and fish, cereals and legumes, oils and fats, fruits and vegetables, beverages and other foods, and food preparations.

In other follow-up waves, the online questionnaires Q_2 (i.e., 2018) and Q_4 (i.e., 2020) were responded to via electronic mail and included variables addressing autonomy in personal hygiene, basic human needs, and food; the occurrence of pregnancies since the end of Q_0; current weight; recent results of biochemical or imaging tests; medication use; lifestyle habits; and the diagnosis of diseases in the previous two years. In addition to questions involving employment status, and questions about lifestyle, such as smoking, drinking alcohol, sleep patterns and exercising habits with information on type of physical activity, frequency, and time spent.

## Outcome variable: maintenance of regular physical activity

The maintenance of regular physical activity was assessed through questions about the practice of physical activity, which was assessed using a list of 23 activity, expressed in minutes or hours per week. Initially, all times were converted to minutes per week[11].

To determine the variable physical activity, the average duration of the intervals selected by the individuals was assessed, based on the questionnaire used to collect data for the research (https://www.projetocume.com.br/questionario). These values were multiplied by the frequency of each activity, and the results were added to obtain the total time spent on physical activity.

The classification of activity intensity was based on metabolic equivalent of task (METs). Activities such as yoga and pilates were classified as light (<3 METs); walking, treadmill walking, weight training, gymnastics, water aerobics, general gymnastics, swimming, volleyball, shuttlecock, mountain biking were classified as moderate (3–6 METs); and running, treadmill running, wrestling, cycling, exercise bike, soccer, indoor soccer, basketball, handball, and tennis were classified as vigorous (>6 METs).

Thus, according to the World Health Organization[12] recommendation, individuals who performed 150 minutes or more per week of moderate physical activity (on a scale relative to an individual's personal capacity, moderate physical activity is usually a 5 or 6 on a rating scale of perceived exertion scale of 0-10) or at least 75 minutes per week of vigorous physical activity (on a scale relative to an individual's personal capacity, vigorous physical activity is usually a 7 or 8 on a rating scale of perceived exertion scale of 0-10) or a combination of the two were considered active. Thus, individuals were classified as insufficiently active if they performed less than 150 minutes of moderate activity or less than 75 minutes of vigorous activity.

The maintenance of regular physical activity during

follow-up was estimated based on the physical activity reported in each wave and across all three waves, considering the same cut-off point described above.

### Independent variables

The independent variables used in this study were: Sociodemographic characteristics (gender: woman or men; age, categorized as < 30, 30 to 50, and ≥ 50 years), marital status (with a partner and without partner), lifestyle habits (cigarette use, never smoker, former smoker and current smoker), alcohol consumption (yes, no), presence of comorbidities (overweight, body mass index ≥ 25 kg/m$^2$, yes, no), type 1 or 2 diabetes mellitus (yes, no), hypertension (yes, no), and food consumption assessed according to the FFQ and the NOVA Food Classification[13].

Individuals who reported obesity (body mass index ≥ 30 kg/m$^2$) or overweight (body mass index ≥25 kg/m$^2$) were classified as overweight[14]. The classification of type 1 or 2 diabetes was estimated based on reports of oral hypoglycemic medications, insulin, medical diagnosis, and/or fasting blood glucose level ≥ 126 mg/dL[15]. Hypertension was based on a medical diagnosis, antihypertensive medications, a systolic blood pressure ≥ 140 mmHg, and/or a diastolic blood pressure ≥ 90 mmHg[16].

Notably, a previous study[17] validated self-reported parameters of metabolic syndrome (body mass index, blood pressure, blood glucose, and total triglyceride and cholesterol) in a sample of participants in this cohort. In this study, moderate agreement (k = 0.41 to 0.60) was observed in the self-reports of all the variables mentioned.

Information on food consumption was extracted from the FFQ, which comprises 144 items validated and with CUME participants[18] having verified satisfactory validity and reproducibility. This makes it suitable for analyzing the association between food consumption and chronic diseases among this cohort.

For each selected food, the participant indicated the portion size expressed in commonly used household measurements used in Brazil (teaspoon, tablespoon, ladle, tip knife, tongs, saucer, cup, and glass) or in traditional portions of food (unit, slices, and pieces) and the usual frequency of consumption (day/week/month/year). The intake frequencies of each food were transformed into daily consumption. Subsequently, the daily food consumption (grams or milliliters) was calculated by multiplying the portion size by the frequency of consumption. Caloric intake (kcal) and nutrients were calculated using the Brazilian Food Composition Table[19].

After this stage, the food items were characterized according to the NOVA classification into natural and minimally processed (NMPF), processed (PF), and ultra-processed (UPF) foods[13]. Before the statistical analyses, the amount of energy from minimally processed, processed, and ultra-processed foods was represented by the percentage (%) of calories/day in the diet using the residual method[20].

### Statistical analysis

The characteristics of participants were expressed as absolute and relative frequencies according to the maintenance of the physical activity, and differences were assessed using Pearson's $\chi^2$ test.

Poisson regression analyses with robust variances were performed to investigate the factors associated with maintaining physical activity during follow-up. Considering that there is an inverse relationship between food consumption at different levels of food processing, more specifically, those who consume more UPFs tend to consume a lower proportion of NMPF, the analysis was performed separately.

The assumptions for the Poisson Regression analysis were met, i.e., the mean of the response variable (maintenance of active life throughout the follow-up) presented a value very close to its variance. The analysis of the adjustments of the models was performed using the Deviance and Pearson's chi-square tests, and the models were considered well-adjusted, which presented a p-value greater than 5%[21]. Differences with p ≤ 0.05 were considered to be statistically significant for all analyses. Statistical analysis was performed using SPSS version 18.0 (IBM Corporation, Armonk, NY, USA).

## Results

### Characteristics of participants

During the 4-year follow-up (2016, 2018, 2020), 40% of participants remained active from baseline to the first wave, 30% from the second to the third wave, and 29% throughout follow-up. The proportion of active individuals at baseline and for each wave, considering physical activity level, can be seen in Figure 1. A positive result is observed at follow-up, as the percentage of physically inactive participants decreased from 57% (baseline) to 49% after 4 years, and the percentage of physically active participants increased from 43% to 51%.

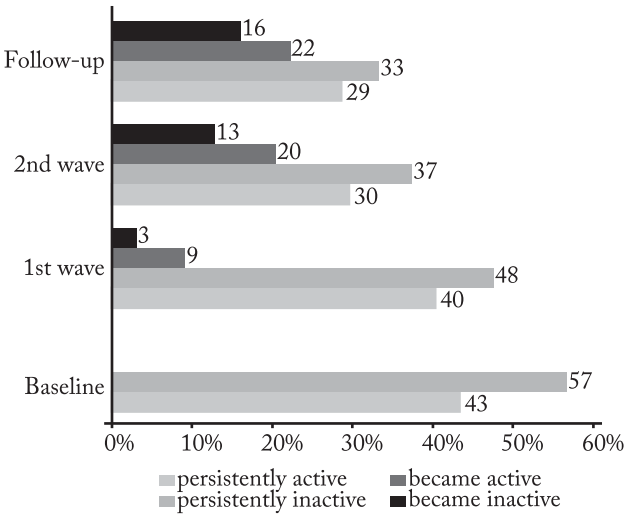


**Figure 1 –** Percentage distribution of participants according to physical activity classification at baseline and at each wave of follow-up.

The characteristics of the participants who remained physically active are presented in Table 1.

**Table 1 –** Characteristics of participants according to the maintenance of the physical activity cohort of the University of Minas Gerais (CUME) study.

| Characteristics | Remained active†† | | p-value* |
|---|---|---|---|
| | Yes (n = 1218) | No (n = 1328) | |
| | n (%) | n (%) | |
| Gender | | | |
| Woman | 421 (34.6) | 442 (33.3) | 0.495 |
| Men | 797 (65.4) | 886 (66.7) | |
| Marital status | | | |
| No partner | 552 (45.3) | 633 (47.7) | 0.236 |
| With partner | 666 (54.7) | 695 (52.3) | |
| Age years | | | |
| < 30 | 354 (29.1) | 345 (26.0) | 0.035 |
| ≥ 30 < 50 | 708 (58.1) | 838 (63.1) | |
| ≥ 50 | 156 (12.8) | 145 (10.9) | |
| Uses cigarettes | | | |
| Never smoker | 976 (80.1) | 1,055 (79.4) | 0.025 |
| No, but I have smoked | 156 (12.8) | 144 (10.8) | |
| Smoke | 86 (7.1) | 129 (9.7) | |
| Uses alcoholic beverages | | | |
| Yes | 923 (75.8) | 928 (29.9) | 0.001 |
| No | 295 (24.2) | 400 (30.1) | |
| Have diabetes€ | | | |
| Yes | 48 (3.1) | 25 (2.4) | 0.297 |
| No | 1,476 (96.9) | 997 (97.6) | |
| Have hypertension‖ | | | |
| Yes | 202 (16.6) | 253 (19.1) | 0.105 |
| No | 1016 (83.4) | 1075 (80.9) | |
| Have overweight/obesity§ | | | |
| Yes | 492 (40.4) | 553 (41.6) | 0.523 |
| No | 726 (59.6) | 775 (58.4) | |
| Consumption of processed foods‡ | | | |
| 1° tertile | 419 (34.4) | 429 (32.3) | 0.409 |
| 2° tertile | 407 (33.4) | 442 (33.3) | |
| 3° tertile | 392 (32.2) | 457 (34.4) | |
| Consumption of ultra-processed foods¥ | | | |
| 1° tertile | 460 (37.8) | 388 (29.2) | <0.001 |
| 2° tertile | 409 (33.6) | 439 (33.1) | |
| 3° tertile | 349 (28.7) | 501 (37.7) | |
| Consumption of natural and minimally processed foods♦ | | | |
| 1° tertile | 345 (30.5) | 502 (37.8) | <0.001 |
| 2° tertile | 409 (33.9) | 441 (33.2) | |
| 3° tertile | 464 (35.5) | 385 (29.0) | |

€Reports of the use of oral hypoglycemic medications, insulin, medical diagnosis, and/or fasting blood glucose ≥126 mg/dL; ‖Reports of medical diagnosis, use of antihypertensive drugs and systolic blood pressure values ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg; §Body mass index ≥ 25 kg/m²; ‡Percentage of calories/day of processed foods in the diet adjusted by caloric intake; ¥Percentage of calories/day of ultra-processed foods in the diet adjusted by caloric intake; ♦Percentage of calories/day of natural and minimally processed foods in the diet adjusted by caloric intake; ††150 min/week of physical activity between 2016 and 2018, between 2018 and 2020 or between 2016 and 2020. *Statistically significant difference (p < 0.05 [Pearson's χ2 test]).

## Maintenance of regular physical activity and its associated factors

The results of the adjusted analysis of factors associated with maintaining physical activity are presented in Tables 2 and 3. Considering that there is an inverse relationship between food consumption at different levels of food processing, more specifically, those who consume more UPFs tend to consume a lower proportion of NMPF. This analysis was performed separately. Thus, the results of the first analysis, that is, of the factors associated with maintaining physical activity and consuming UPFs, are summarized in Table 2.

The results presented in Table 2 indicate that participants aged between 30 and 50 years (p = 0.005), who were smokers (p = 0.003), and who consumed more significant proportions of energy from UPFs were less likely to remain physically active throughout the cohort's follow-up while consuming alcoholic beverages was a variable that increased this probability (p < 0.001).

Table 3 presents the results of the adjusted analysis of variables associated with maintaining of physical activity according to NMPF consumption. The results indicate that participants aged between 30 and 50 years (p = 0.012) and smokers (p = 0.015) were less

**Table 2 –** Multivariate analysis of variables associated with the maintenance of physical activity by CUME participants throughout the follow-up (n = 2,546).

| Characteristics | PR Adjusted (95% CI) | p-value* |
|---|---|---|
| Age years) | | |
| < 30 | 1 | |
| ≥ 30 < 50 | 0.94 (0.89 - 0.98) | 0.005 |
| ≥ 50 | 0.99 (0.92 - 1.06) | 0.717 |
| Uses alcoholic beverages | | |
| Yes | 1.09 (1.04 - 1.14) | <0.001 |
| No | 1 | |
| Uses cigarettes | | |
| Never smoker | 1 | |
| No, but I have smoked | 1.02 (0.96 - 1.08) | 0.607 |
| Smoke | 0.90 (0.84 - 0.97) | 0.003 |
| Have hypertension‡ | | |
| Yes | 0.96 (0.91 - 1.01) | 0.112 |
| No | 1 | |
| Consumption of ultra-processed foods** | | |
| 1° tertile | 1 | |
| 2° tertile | 0.94 (0.83 - 0.98) | 0.007 |
| 3° tertile | 0.87 (0.89 - 0.92) | <0.001 |

‡Reports of the medical diagnosis, use of antihypertensive medications, and systolic blood pressure values ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg; **Percentage of calories/day of ultra-processed foods in the diet adjusted by caloric intake in tertile; *Statistically significant difference (p < 0.05 [Poisson regression analysis]). Model adjustment tests: Deviance (p-valor = 0.726) e Pearson's $\chi^2$ (p-valor = 0.601)

**Table 3 –** Multivariate analysis of variables associated with maintaining physical activity by CUME participants throughout the follow-up (n = 2,546).

| Variables | PR Adjusted (95% CI) | p-value |
|---|---|---|
| Age years) | | |
| < 30 | 1 | |
| ≥ 30 < 50 | 0.94 (0.90 - 0.99) | 0.012 |
| ≥ 50 | 0.99 (0.92 - 1.07) | 0.869 |
| Uses alcoholic beverages | | |
| Yes | 1.10 (1.05 - 1.15) | <0.001 |
| No | 1 | |
| Uses cigarettes | | |
| Never smoker | 1 | |
| No, but I have smoked | 1.02 (0.96 - 1.09) | 0.532 |
| Smoke | 0.92 (0.85 - 0.98) | 0.015 |
| Have hypertension‡ | | |
| Yes | 0.96 (0.96 - 1.01) | 0.151 |
| No | 1 | |
| Consumption of natural and minimally processed foods** | | |
| 1° tertile | 1 | |
| 2° tertile | 1.07 (1.02 - 1.13) | 0.004 |
| 3° tertile | 1.15 (1.09 - 1.20) | <0.001 |

‡Reports of the medical diagnosis, use of antihypertensive medications, and systolic blood pressure values ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg; **Percentage of calories/day of natural and minimally processed foods in the diet adjusted by caloric intake in tertile; *Statistically significant difference (p < 0.05 [Poisson regression analysis]), Model adjustment tests: Deviance (p-valor= 0.724) e Pearson's $\chi 2$ (p-valor =0.601)

likely to remain physically active throughout the cohort's follow-up while consuming alcoholic beverages (p < 0.001) and that consuming greater proportions of energy from the NMPF were variables that increased this probability (p < 0.001).

## Discussion

The present study analyzed the maintenance of physical activity over a four-year follow-up period in a cohort of young Brazilian adults and the factors associated with this maintenance. The results indicate that a reasonable number of individuals remained active throughout the follow-up.

Despite the importance of regular physical activity in preventing and treating many chronic diseases[1,3,5,6], few publications have addressed whether people with chronic diseases maintain physical activity throughout their lives and which factors are protective for this maintenance.

This information is important because it can help managers and health professionals monitor the goals established as priorities in national, regional, and global plans to address the challenge(s) of chronic disease. In this study, we observed that having chronic diseases, such as hypertension, diabetes, or obesity, was not a protective factor for maintaining physical activity, even though it is widely known that this practice can not only prevent these diseases but also help control them. This indicates the need to reinforce the maintenance of this practice in groups with these diseases.

The maintenance of physical activity varied accord-

ing to the years studied. We chose to analyze waves 2016 to 2018, 2018 to 2020, and 2016 to 2020 because this was an open cohort study; new participants were included every two years. A maintenance of physical activity of 29% throughout follow-up is a worrying result, and corroborates the study[22], which indicated that in Brazil, adults aged 18 years and over, 40 and 49.9% were not sufficiently active in 2022.

A study investigating the maintenance of physical activity among participants in the Pelotas birth cohort[23] reported that 74.6%, 40.4%, and 37.3% of participants remained active (physical activity ≥ 150 minutes/week) for more than 23 years in 1997, 2001, and 2004, respectively. Although the present study included only 4 years of follow-up, it presented a trend similar to that of this study.

It is worth noting that most participants in this study were young adults. They are at a stage when they are getting married, becoming pregnant, and transitioning into parenthood. According to a survey conducted by Gropper et al.[24], this is a stage when physical activity tends to decrease.

Participants who smoke are 10% (Table 2) and 8% (Table 3) less likely to remain active throughout follow-up. Other study also indicate that smokers are less physically active[25]. The opposite has also been observed; physically active people smoke less. Alcohol consumption has also been associated with an active lifestyle.

Engagement in recreational physical activity can cause the body to release endorphins and dopamine, which can provide people with a positive emotional experience, which may also be one of the reasons for reducing smoking behavior[26]. In turn, cigarettes can provide smokers with a feeling of well-being similar to that provided by physical activity, and therefore, they may be less active. Furthermore, smokers may adhere less to physical activity because smoking impairs physical fitness, even among relatively young and fit individuals, so smokers also have less resistance[27], and this may favor lower adherence to physical activity throughout follow-up.

The results of this research confirm that physically active individuals consume more alcoholic beverages than non-active individuals[28,29]. Alcoholic beverage users were approximately 10% more likely to remain active. Lima et al.[28] also reported that active adults living in Curitiba, Paraná State, Brazil were 50% more likely to consume alcoholic beverages regularly. In the review by Dodje et al.[30], almost 88% of studies involving university students and 75% of those involving nonstudent adults demonstrated a positive relationship between physical activity and the consumption of alcoholic beverages.

Personality characteristics influence physical activity and consumption of alcoholic beverages. Active individuals commonly have more social relationships, which can favor greater consumption of alcoholic beverages[28]. Additionally, some individuals may become aware of their drinking quantity and frequency and make conscious decisions to counteract adverse health effects associated with drinking by engaging in more physical activity[31]. In addition, consideration of the impact of alcohol and physical activity on the brain is important for understanding why these two behaviors are linked. The positive association between activity and alcohol intake may partly stem from both representing rewarding stimuli that activate the brain's mesocorticolimbic pathway. Another important circuit affected by activity and alcohol is the hypothalamic-pituitary-adrenal axis, a key effector system involved in energy metabolism and stress responses. It is, therefore, conceivable that people who are not dependent on either alcohol or physical activity may engage moderately in both regularly to prolong positive affect[31].

In this study, we found that people with NCDs did not have a more active lifestyle than those without NCDs. Similar results were found in other studies that evaluated the level of physical activity in individuals with hypertension, and an inverse relationship was found between physical activity and the prevalence of this disease[32]. This result is worrisome because physical activity is considered to be an important adjunct in the treatment of arterial hypertension owing to its hypotensive effects, even after a single session. In addition, a significant reduction in blood pressure can be maintained throughout a structured physical training program[33].

Duclos et al.[34] reported that patients with hypertension and sedentary behavior reported more barriers to, and fewer motivations for, the practice of physical activity than did physically active patients, with the most reported barriers including "self-image," "lack of support and encouragement," and "concerns about health and fear of injury." In a study by Murta et al.[35], which aimed to identify barriers to the practice of activity in patients with NCDs, the most reported barriers included the following: "Having a good diet and taking the medication correctly are enough to treat your disease"; "Shortness of breath, chest pain, racing heart or dizziness"; "Fear of pain, shortness of breath, dizziness,

hypoglycemia, blood pressure changes"; "Fear of falling or getting hurt"; and "Pain, tiredness or leg cramps."

People who are more physically active are less likely to smoke[36]. This finding reinforces the perception that physically active individuals tend to adopt other positive health habits. In the present research, participants with higher energy consumption from NMPF were more likely to remain physically active throughout the cohort follow-up. Conversely, people with higher UPF consumption tended to exhibit more sedentary behaviors. Silva et al.[37] evaluated usual UPF consumption and its association with sex, age, physical activity, and body mass index in adults in Brasília, Federal District, Brazil. They found that those who were overweight or obese and sedentary exhibited a more significant percentage of UPF energy consumption than those who were eutrophic and active.

As a limitation of this study, the information was collected through an online questionnaire, and all responses were self-reported by the participants. Thus, health conditions such as diabetes, hypertension, and excess weight were self-reported by the participants; however, a previous study[17] validated the self-reported parameters of metabolic syndrome (body mass index, blood pressure, blood glucose, total triglyceride cholesterol) in a sample of participants in this cohort. The FFQ used in this study was also validated with CUME participants[18]. Despite this, we cannot disregard the possibility of incorrect classification of some foods according to the NOVA classification due to the lack of details about the foods, as the FFQ used was not designed to collect data considering this new classification of foods. In its validation, the correlation coefficient for the group of unprocessed/minimally processed foods and culinary preparations was low (0.36); however, it was close to the acceptable value (0.40).

Furthermore, we cannot assume that the sample evaluated in the CUME is representative of all graduates and undergraduates of the universities included in this study since, as previously reported, we cannot say how many graduates and undergraduates received the invitation to participate in the research. Despite this, the generalization of results in epidemiology should be based on biological mechanisms rather than statistical representativeness[38]. Finally, it is essential to note that this result pertains to cohort participants and cannot be generalized to the broader population.

In summary, many of the participants from the CUME group remained active throughout the four-year follow-up. However, participants aged between 30 and 50 years, smokers and those who consume large amounts of ultra-processed foods were less active. Maintaining an active lifestyle can contribute to a better quality of life and better control of chronic diseases. Maintaining practice of physical activity, in addition to helping to improve quality of life, can promote better control of chronic diseases such as obesity, diabetes, and hypertension, which many people suffer from.

In this way, public health plays a significant role in implementing standardized physical activity surveillance procedures to increase this practice. Evaluating the factors associated with maintaining this practice is necessary to understand which intervention strategies should be used for different populations and to identify populations at the highest risk for sedentary lifestyle.

## Conflict of interest

The authors declare no conflict of interest.

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## Author's contributions

Rodrigues TCP: Conceptualization; Formal analysis; Visualization; Writing – original draft; Writing – review & editing; Approval of the final version. Pimenta AM: Conceptualization; Methodology; Validation; Investigation; Project administration; Funding acquisition; Writing – review & editing; Approval of the final version. Costa Sobrinho PS: Formal analysis; Investigation; Resources; Visualization; Writing – review & editing; Approval of the final version. Hermsdorff HHM and Bressan J: Methodology; Investigation; Project administration; Funding acquisition; Writing – review & editing; Approval of the final version. Nobre LN: Conceptualization; Formal analysis; Investigation; Supervision; Project administration; Visualization; Writing – original draft; Writing – review & editing; Approval of the final version.

## Declaration regarding the use of artificial intelligence tools in the article writing process

The authors did not use artificial intelligence tools for preparation of the manuscript.

## Availability of research data and other materials

The data of this study is available on demand from referees.

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# Reviewers' assessment

The reviews of this article were originally conducted in Portuguese. This version has been translated using ChatGPT and subsequently reviewed by the Chief Editors.

## Reviewer A

Anonymous

### Format

- Does the article comply with the manuscript preparation rules for submission to the Revista Brasileira de Atividade Física e Saúde?
  Yes
- Regarding formal aspects, is the manuscript well-structured, containing the sections: introduction, methods, results, and discussion (with the conclusion as part of the discussion)?
  Yes
- Is the language appropriate, with clear, precise, and objective text?
  Yes
- Was any indication of plagiarism observed in the manuscript?
  No
  **Suggestions/comments:**
- The article has an adequate structure and is organized in a clear and objective way.

### Abstract

- Are the abstract and resumo adequate (containing: objective, information about study participants, studied variables, main results, and a conclusion) and do they reflect the content of the manuscript?
  Yes
  **Suggestions/comments:**
- The abstract reflects the main findings of the article. However, in its last sentence (recommendations), the idea of "encouraging PA" among smokers and people with inadequate diet does not seem appropriate. A more suitable message would be investing in health education in general, including the risky health behaviors mentioned.

### Introduction

- Was the research problem clearly stated and delimited?
  Yes
- Is the research problem adequately contextualized in relation to the available knowledge, moving from general to specific?
  Yes
- Are the reasons that justify the study (including the authors' assumptions about the problem) well established?
  Yes
- Are the references used to support the presentation of the research problem current and relevant to the topic?
  Yes
- Was the objective clearly stated?
  Yes
  **Suggestions/comments:**
- The article, in general, is well written and its organization is adequate. However, it is necessary to provide the full description of all acronyms at their first appearance in the text. This requires revising the text from the introduction onwards.

### Methods

- Are the methodological procedures generally adequate for studying the research problem?
  Yes
- Are the methodological procedures adopted in the study sufficiently detailed?
  Yes
- Was the procedure adopted for the selection or recruitment of participants adequate for the problem studied and described in a sufficient, clear, and objective way?
  Partially
- Were details provided about the instruments used for data collection, their psychometric properties (e.g., reproducibility, internal consistency, and validity), and, when relevant, about the operational definition of variables?
  Yes
- Is the data analysis plan adequate and well described?
  Yes
- Were the inclusion and/or exclusion criteria for study participants described and appropriate?
  Yes
- Did the authors provide clarifications about the

ethical procedures adopted in the study?
Yes
**Suggestions/comments:**
- In the first paragraph of the methods section, it is necessary to correct the description of the study cohort.
- In the last paragraph of the section on study design and participants, it is necessary to correct the information regarding Research Ethics Committee approval.

## Results

- Is the use of tables and figures appropriate and do they facilitate the clear presentation of the study results?
  Partially
- Is the number of illustrations in the article consistent with the journal's submission guidelines?
  Yes
- Is the number of participants at each stage of the study, as well as the number and reasons for losses and refusals, presented in the manuscript?
  Yes
- Are the participants' characteristics presented and sufficient?
  Yes
- Are the results adequately presented, highlighting the main findings and avoiding unnecessary repetitions?
  Partially
  **Suggestions/comments:**
- The information about the main study variable (maintenance of PA over time) deserves greater emphasis. I suggest including a graph showing the proportion of active individuals at baseline and, for each follow-up, describing the group according to PA level in the previous assessment (% persistently active; % persistently inactive; % became active; % became inactive).
- In Table 1, the symbols need revision. The dependent variable (remained active) is identified with a different symbol from the one described in the table's footnote.

## Discussion

- Are the main study findings presented?
  Yes
- Are the study's strengths and limitations presented and discussed?
  Yes
- Are the results discussed considering the study's limitations and the knowledge already available?
  Yes
- Are the potential contributions of the main findings for scientific development, innovation, or real-world interventions discussed by the authors?
  Yes
  **Suggestions/comments:**
- The authors adequately discuss the association between NCDs and health behaviors with the maintenance of PA levels across follow-ups, with emphasis on the apparently controversial relationship with alcohol consumption.

## Conclusion

- Was the study conclusion adequately presented and consistent with the study's objective?
  Yes
- Is the study conclusion original?
  Yes
  **Suggestions/comments:**
- No suggestions regarding the conclusions.

## References

- Are the references updated and sufficient?
  Yes
- Are most of them composed of original articles?
  Yes
- Do the references follow the journal's guidelines (quantity and format)?
  Yes
- Is citation in the text adequate, i.e., do the statements cite references that substantiate them?
  Yes
  **Suggestions/comments:**
- No suggestions regarding these items.

## Comments to the author

Dear Authors,

The present article, after minor revisions, has potential for publication in this journal.

## Final decision

- **Minor revisions required**

## Reviewer B

Anonymous

### Format

- Does the article comply with the manuscript preparation rules for submission to the Revista Brasileira de Atividade Física e Saúde?
  Yes
- Regarding formal aspects, is the manuscript well-structured, containing the sections: introduction, methods, results, and discussion (with the conclusion as part of the discussion)?
  Yes
- Is the language appropriate, with clear, precise, and objective text?
  Yes
- Was any indication of plagiarism observed in the manuscript?
  No
  **Suggestions/comments:**
- The topic proposed by the authors ("Factors associated with the longitudinal maintenance of active life among participants of the CUME/Brazil study") is very welcome because, in addition to being relevant, the central theme is still little explored in the field of public health. Not only from an epidemiological perspective but also from a sociological one, monitoring behaviors related to physical exercise represents an important research subject, especially in the Brazilian context.

### Abstract

- Are the abstract and resumo adequate (containing: objective, information about study participants, studied variables, main results, and a conclusion) and do they reflect the content of the manuscript?
  Partially
  **Suggestions/comments:**
- In the abstract: include the strength of association for each variable.
- Keywords: although "exercise" is listed as an alternative descriptor, I suggest replacing it with the main descriptor "physical exercise."

### Introduction

- Was the research problem clearly stated and delimited?
  Partially
- Is the research problem adequately contextualized in relation to the available knowledge, moving from general to specific?
  Partially
- Are the reasons that justify the study (including the authors' assumptions about the problem) well established?
  Yes
- Are the references used to support the presentation of the research problem current and relevant to the topic?
  Yes
- Was the objective clearly stated?
  Partially
  **Suggestions/comments:**
- I consider the introduction to be the weakest part of the article under review. Already in the second paragraph, the authors contextualize sedentary behavior; however, this variable was not assessed in the study. It should be noted that sedentary behavior is an independent risk factor from regular physical activity, which is the central object of investigation in this research. In addition, a conceptual review of the terms physical activity and physical exercise is needed throughout the introduction. Later, the authors justify the study with the passage: "Despite the benefits of physical activity/exercise for the prevention and control of chronic diseases, few studies have attempted to assess whether people with NCDs are more likely to maintain physical exercise. In this context, considering the high cost of treating NCDs." This proposes a study that does not match the objective presented in the abstract. It is necessary to standardize/define the central objective of the investigation: "to evaluate the longitudinal maintenance of active life among participants of the Minas Gerais University Cohort (CUME)/Brazil and associated factors" or "to evaluate whether NCDs and sociodemographic variables are factors associated with the longitudinal maintenance of active life among participants of the CUME/Brazil study." It should also be noted that the variables of association were not limited to NCDs, since dietary habits, alcohol consumption, and smoking were also included in the analysis plan and presented as associated factors in the outcomes.

### Methods

- Are the methodological procedures generally adequate for studying the research problem?
  Yes

- Are the methodological procedures adopted in the study sufficiently detailed?
  Yes
- Was the procedure adopted for the selection or recruitment of participants adequate for the problem studied and described in a sufficient, clear, and objective way?
  Yes
- Were details provided about the instruments used for data collection, their psychometric properties (e.g., reproducibility, internal consistency, and validity), and, when relevant, about the operational definition of variables?
  Yes
- Is the data analysis plan adequate and well described?
  Yes
- Were the inclusion and/or exclusion criteria for study participants described and appropriate?
  Yes
- Did the authors provide clarifications about the ethical procedures adopted in the study?
  No
  **Suggestions/comments:**
- There is no information such as: "The research project was initially approved by the Human Research Ethics Committees of XXXX and XXXX (Protocol No. XXXX) and subsequently approved by all institutional participants of the study."

## Results

- Is the use of tables and figures appropriate and do they facilitate the clear presentation of the study results?
  Yes
- Is the number of illustrations in the article consistent with the journal's submission guidelines?
  Yes
- Is the number of participants at each stage of the study, as well as the number and reasons for losses and refusals, presented in the manuscript?
  Yes
- Are the participants' characteristics presented and sufficient?
  Yes
- Are the results adequately presented, highlighting the main findings and avoiding unnecessary repetitions?
  Yes
  **Suggestions/comments:**
- Results: I consider the results presented sufficient and adequate.

## Discussion

- Are the main study findings presented?
  Yes
- Are the study's strengths and limitations presented and discussed?
  Yes
- Are the results discussed considering the study's limitations and the knowledge already available?
  Yes
- Are the potential contributions of the main findings for scientific development, innovation, or real-world interventions discussed by the authors?
  Yes
  **Suggestions/comments:**
- Overall, the discussion is adequate, presenting an analysis that highlights the specificity of the study's findings while placing them in dialogue with national and international literature. However, it is necessary to revise the final part of the discussion, where the authors return to the topic of sedentary behavior, which could cause conceptual confusion within the academic community.

## Conclusion

- Was the study conclusion adequately presented and consistent with the study's objective?
  Yes
- Is the study conclusion original?
  Yes
  **Suggestions/comments:**
- Adequate.

## References

- Are the references updated and sufficient?
  Yes
- Are most of them composed of original articles?
  Yes
- Do the references follow the journal's guidelines (quantity and format)?
  Yes
- Is citation in the text adequate, i.e., do the statements cite references that substantiate them?
  Yes
  **Suggestions/comments:**
- Adequate and sufficient.

## Comments to the author

- The topic proposed by the authors ("Factors associated with the longitudinal maintenance of active life among participants of the CUME/Brazil study") is very welcome because, in addition to being relevant, the central theme is still little explored in the field of public health. Not only from an epidemiological but also from a sociological perspective, monitoring behaviors related to physical exercise represents an important research subject, especially in the Brazilian context. The article is commendable for this initiative and demonstrates solid theoretical and methodological depth, clearly evidenced through well-founded and consistent analyses. This is, in my view, where the manuscript's greatest credibility lies. It presents an innovative and appropriate methodological approach and provides the academic community with theoretical support to expand this debate. However, I suggest important adjustments to make the article suitable for publication in this journal. There are issues regarding methodological definitions, terminology, and concepts:
- In the abstract: include the strength of association for each variable.
- Keywords: although "exercise" is an alternative descriptor, I suggest replacing it with the main descriptor "physical exercise."
- Introduction: I consider the introduction to be the weakest part of the article. Already in the second paragraph, the authors contextualize sedentary behavior, which was not assessed in this study. It should be noted that sedentary behavior is an independent risk factor from regular physical activity, which is the central object of investigation. In addition, a conceptual review of the terms physical activity and physical exercise is needed throughout the introduction. Later, the authors justify the study with the passage: "Despite the benefits of physical activity/exercise for the prevention and control of chronic diseases, few studies have attempted to assess whether people with NCDs are more likely to maintain physical exercise. In this context, considering the high cost of treating NCDs." This proposes a study that does not match the objective presented in the abstract. It is necessary to standardize/define the central objective of the investigation: "to evaluate the longitudinal maintenance of active life among participants of the Minas Gerais University Cohort (CUME)/Brazil and associated factors" or "to evaluate whether NCDs and sociodemographic variables are factors associated with the longitudinal maintenance of active life among participants of the CUME/Brazil study." The variables of association were not limited to NCDs, since dietary habits, alcohol consumption, and smoking were also included in the analysis plan and presented as associated factors in the outcomes.
- Methods: Missing information regarding study design and ethical aspects (e.g., "The Cohort of XXXX is an observational study. The research project was initially approved by the Human Research Ethics Committees of XXXX and XXXX (Protocol No. XXXX) and subsequently approved by all institutional participants of the study.").
- Discussion: Overall adequate, presenting an analysis that values the specificity of the study's findings while situating them in dialogue with national and international literature. However, it is necessary to revise the final part of the discussion, where the authors return to the issue of sedentary behavior, which may cause conceptual confusion within the academic community.
- Results: I consider the results presented sufficient and adequate.

## Final decision

- Minor revisions required