



Neutrosophic statistical analysis of cardiovascular disease prevention from a physical culture in urban communities

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Abstract. The research presented here considers the educational potential of physical activities for disease prevention. Its objective is to elaborate a physical-educational intervention strategy for the prevention of cardiovascular diseases in urban communities in the department of Cundinamarca, Colombia. The research was carried out in the municipalities of Funza, Fusagasugá Albán, and Supatá in the department of Cundinamarca in Colombia, based on the theoretical foundations of prophylactic and therapeutic physical culture and related sciences for disease prevention. Theoretical, empirical, and mathematical-statistical scientific methods were applied. In addition, neutrosophic techniques were used to validate the study. The results indicate an adequate level of statistical significance. Future work should focus on expanding the use of neutrosophic methods to enhance cardiovascular disease prevention efforts across diverse and vulnerable populations, improving decision-making and adaptability in community health programs.

Keywords: neutrosophic, neutrosophic statistics, prevention, cardiovascular diseases, urban communities.

1 Introduction

The World Health Organization (WHO) [1] estimated in 2011 that 6 out of 10 deaths and 70% of disability-adjusted life years are due to noncommunicable diseases. It is also projected that by 2030 more than three quarters of deaths will be due to NCDs. Today, in the Americas region, approximately 77% of deaths and 69% of the burden of disease are due to NCDs. On the other hand, WHO [1] also considers that the lack of physical activity is a considerable risk factor for this type of disease, where sedentary behavior is typical of the way of living, consuming, and working in advanced societies.

NCDs are of long duration and slow progression. More than 80% of deaths are due to cardiovascular diseases, type II diabetes, and about one-third of cancers. The latter can be prevented by eliminating the risk factors they share, such as tobacco use, poor dietary habits, and physical inactivity, all of which are preventable [2].

Accordingly, this study focuses on cardiovascular diseases (CVD), as they have the highest incidence and prevalence in the world population and South America in particular. These diseases are currently responsible for 60% of all deaths worldwide, and 80% of these occur in low- and middle-income countries such as Colombia [3].

Concerning this, the Executive Committee of the World Health Organization stated that cardiovascular disease; has reached enormous proportions and affects younger and younger people. In the coming years, if this trend does not change through research to identify its causes and how to prevent it, it will become the greatest epidemic of mankind, [1].

To go deeper into the subject, the author of the research conducted an initial bibliographic search

where Alvarez [4] stands out, whose research is aimed at the treatment of hypertensive patients and offers an improvement strategy for Physical Education teachers, aimed at the treatment of obesity. It also stands out [5], [6] those who carry out the protocol of disease prevention in primary health care; however, it should be noted that it is only aimed at guiding the patient in what to do, without reflecting the methodological guidelines for its practical implementation.

The research developed by [2], who elaborated a physical exercise program for the prevention of cardiovascular diseases in patients in the Republic of Congo, stands out; the actuality and novelty of this research are recognized, however, to achieve its implementation in the current context, it requires the sensitization of the actors and the formation of healthy habits and lifestyles; which shows that the educational perspective is a viable tool.

On the other hand, the program of the therapeutic areas of physical culture and the work for Physical Activity teachers in the community are reflected in the normative documents of Inder, but they do not contain educational actions that promote the prevention of these diseases.

In the particular case of Colombia, the Ten-Year Public Health Plan in the years 2012 - 2021, outlines the pillars for the prevention of these diseases, where the standards and dimensions for a healthy habitat are defined, as described in the Department of Cundinamarca, in Colombia [7]. Based on the above, actions and strategies should be established to promote their contextualization, based on the requirements and characteristics of each of the states of the country.

Specifically, in the department of Cundinamarca, in Colombia, the main causes of mortality in the period 2005-2018 were, in the first place, non-communicable diseases and cardiovascular diseases (CVD) which represented 35%, in second place, those of group of other causes, with 26%; in third place, neoplasms, which represent 16% of the mortality of the department, according to the Ten-Year Public Health Plan, [7].

In a diagnosis carried out in the urban communities of the Department of Cundinamarca of Colombia, where interviews, surveys, a documentary review, and the study of the initial bibliographic sources were applied; these instruments evidenced the main results, which are enunciated below:

- The existence of an adequate integration of the main actors of the urban community to enhance the prevention of cardiovascular diseases from the physical-educational point of view.
- Urban dwellers have insufficient knowledge of the benefits of community physical culture for the prevention of cardiovascular diseases.
- Few tools integrate physical education in the process of prevention of cardiovascular diseases in urban communities in Colombia.

In correspondence with the above, the following scientific problem is stated: How to assess the prevention of cardiovascular diseases in the process of physical culture for urban communities in the department of Cundinamarca, Colombia?

Following the above, it is recognized as a research objective: to apply neutrosophic statistics to assess the prevention of cardiovascular diseases in the process of physical culture for urban communities in the department of Cundinamarca, Colombia.

2 Materials and methods

A set of theoretical, empirical, and mathematical-statistical methods and techniques were taken into account for this research. These were found in correspondence with the stages of the work:

Methods of the theoretical level

The historical-logical one, allowed the study of the main antecedents of the educational intervention in the prevention of diseases in urban communities, in addition to the chronological and logical of the events presented.

The analytical-synthetic approach made it possible to break down the object of study (the preventive process of physical culture in cardiovascular diseases) into its different parts, to establish the system

of essential relationships between the psychosocial, pedagogical, biological, and medical foundations; it was also used for the presentation of the results, the partial and conclusions.

The inductive-deductive approach allowed the contextualization of knowledge related to the educational intervention in the prevention of cardiovascular diseases in urban communities, to increase the knowledge of urban dwellers regarding the risk factors of these diseases.

The system approach provided the general orientation of the educational intervention, based on the hierarchical structuring of each structure of the elaborated strategy (introduction, foundation, diagnosis, strategic planning, instrumentation, and evaluation), by establishing the relationships of subordination or coordination among its constituent elements; in which the components, structure, functional relationships and hierarchy of it are denoted.

Empirical level methods

Non-participant scientific observation. It was also carried out in the exploratory study stage, in the diagnosis and its follow-up to know the behavior of the implementation of the educational intervention in the prevention of cardiovascular diseases, in the urban communities of the department of Cundinamarca in Colombia.

The survey made it possible to deepen particular aspects of the educational intervention in the prevention of cardiovascular diseases in the urban communities of the Department of Cundinamarca in Colombia; and also to know the opinions of the different actors and decision-makers about the object of the research and the verification of the feasibility of the proposal.

The documentary analysis allowed the study of official documents such as the Health Situation Analysis of Cundinamarca, the Integral Health Routes, and the Disease Prevention Strategy of the Government of Cundinamarca.

Methodological triangulation was applied to the different research methods and techniques to evidence and verify similarities and differences between the data and information. Different instruments were used to ratify the conclusions or assessments. These include the survey, interview, and documentary review.

Pedagogical experiment pre-experimental design: with pretest and post-test for one group. The research fieldwork was conducted in the period from February 2021 to February 2022.

Mathematical statistical methods

From descriptive statistics, empirical distributions of absolute and relative frequencies were used, these expressed in percentages, their graphic representations, and numerical measures such as mode, mean, and standard deviation.

From the inferential statistics, the Mc Nemar nonparametric test for related samples was used to test the significance of the changes before and after the intervention. This is a before-and-after hypothesis test with the particularity that it is only applicable to dichotomous variables; it allows us to know whether a YES or NO response varies from one moment to the next.

2.1 Population and sample

A neutrosophic sample is a set of elements that are characterized by having properties that cannot be determined with certainty, i.e., that can have degrees of truth, falsity, and indeterminacy. In other words, a neutrosophic sample is composed of elements for which the truth, falsity, or indeterminacy of certain properties are not known precisely, [7].

In neutrosophic set theory, a neutrosophic sample is represented by a three-dimensional vector (T, I, F) , where:

T represents the degree of truth membership indicating the membership of an element to a specific property.

I represent the degree of indeterminacy membership, which reflects the uncertainty or ambiguity about the property.

F represents the degree of falsehood membership, which indicates the non-membership of an element to the property.

Each of these values ranges from 0 to 1, where 0 means that the property is completely false, 1 means that it is completely true and 0.5 denotes that it is completely indeterminate.

Neutrosophic set theory and neutrosophic samples are applied in fields such as artificial intelligence, medicine, and others, for decision-making, fuzzy logic, and imprecise reasoning, where uncertainty and imprecision in data and information need to be handled. These tools are useful when facing problems where the available information is vague or incomplete, allowing to represent and process knowledge more broadly and flexibly, [8].

Based on the above, the following procedure is presented for the selection of the sample under study in this research:

The desired confidence level (95%) is defined.

The acceptable margin of error is established ($\pm 5\%$).

The formula used to calculate the required sample size is the formula for finite populations:

N = population.

Z = critical value based on the confidence level (e.g., for a confidence level of 95%, $Z \approx 1.96$).

p = estimated proportion (0.5 was used if you do not have a prior estimate).

$q = 1 - p$.

E = margin of error as a proportion (0.05).

$$n = \frac{(Z^2 * p * q)}{\frac{E^2}{(N - 1)} + Z^2 * p * q} \quad (1)$$

Applying these values in the formula:

$$n = (1.96^2 * 0.5 * 0.5) / (0.05^2 / (2625 - 1) + 1.96^2 * 0.5 * 0.5)$$

$$n \approx 130.78$$

The sample studied consisted of a total of 125 urban dwellers, distributed by strata of 4 municipalities of the department, these were chosen at random, in addition to stratified random sampling, according to the procedure and spreadsheet of the University of Murcia Spain and the sample was structured as follows: (Funza ($n = 30$), Fusagasugá ($n = 30$), Albán ($n = 30$) and Supatá ($n = 35$). Overall, 56 males and 69 females, aged between 22 and 51 years), randomly selected, using the letter selection procedure.

Table 1. Distribution of behavior by sex and age of the selected sample.

Municipality sex Age	Male sex	Female sex	(mean $\pm$ SD)
Funza (30)	15	17	31.1 $\pm$ 13.6
Fusagasugá (30)	11	19	46.7 $\pm$ 10.2
Albán (30)	13	17	39,6 $\pm$ 10.1
Supatá (35)	17	16	44.5 $\pm$ 9.7
TOTAL (125)	56	69	44.3 $\pm$ 10.8

The study followed the postulates of the Declaration of Helsinki, where all subjects gave their consent and received the information required for the study.

2.2 Neutrosophic method

In correspondence with the methods and approaches assumed in the research, single-valued neutrosophic sets (SVNS) [7] [8], [9] were used from the neutrosophic perspective, which allow the use of linguistic variables that increase the interoperability in the recommendation models and the use of indeterminacy [10], [11], [12], [13], [14].

Neutrosophic sets are a generalization of a fuzzy set (spatially of an intuitionistic fuzzy set) [13]. Let U , a universe of discourse, and M be a set included in U . An element to x of U is noted in respect of the set M as $x(T, I, F)$ and belongs to M in the following way [16, 17]:

Statistically T, I, F are subsets, but dynamically T, I, F are functions or operations dependent on many unknown or known parameters [14]. Let X be a universe of discourse. An SVN SA over X is an object of the form:

$$A = \{ (x, u_{A(x)}, r_{A(x)}, v_{A(x)}) : x \in X \} \quad (2)$$

For work with neutrosophic numbers, neutrosophic statistics have also been defined [10], [11]. The confidence interval represents an application domain of applied neutrosophic statistics [12]. The population sample neutrosophic confidence interval can be defined in the same way as the classical large sample confidence interval for the population proportion π [14].

$$p \pm (\text{Critical value } Z) * \text{sqrt} \left(\frac{(p * (1 - p))}{n} \right) \quad (3)$$

For a confidence level of ≥ 5 .

Derived from the above and to perform neutrosophic statistical analysis, the following methodological algorithm was taken into account, which illustrates the developed logic (Figure 1). Each of its phases is a step of progress in the research developed, where the problem arises from a valuation need that is represented.

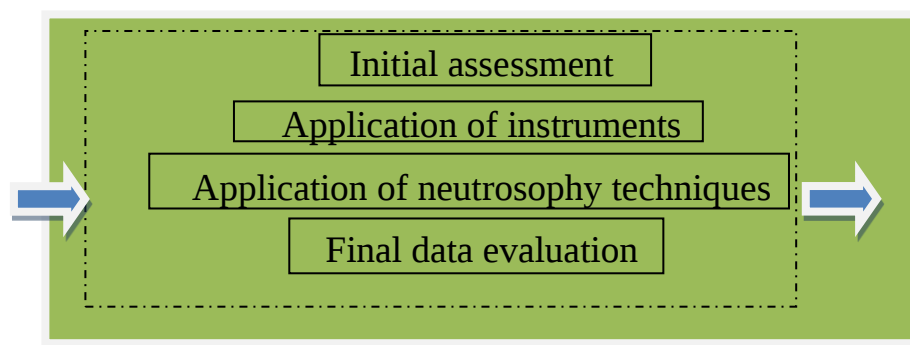


Figure 1. Schematic representation of the neutrosophic logic followed in the research.

3 Results and discussion

In this section we present the results obtained for this pre-experimental design was developed as follows:

- Initial evaluation (before)
- Application of an educational intervention strategy.
- Final evaluation (after application).

Indicator knowledge of risk factors

When answering question 1 of the survey, it becomes evident that before applying the strategy, the majority did not know the risk factors for cardiovascular diseases. A total of 96, 80% did not know at this time of the investigation what the risk factors for the disease under investigation were. However, once the educational intervention strategy was applied, this situation was transformed, since 113 (94.1%) revealed that they did know. It is important to note that most of them argued that they had learned about it during the period of the research, a result that shows the influence of the research on the urban dwellers who participated in the research.

The following are two examples of what was reflected by the residents concerning the contents of this indicator. An example of this is that, when arguing their response, they applied the strategy that there was a group of people who used tobacco or cigarettes (88 for 73.3%), in the case of the latter up to more than 5 per day. After the educational intervention, the number of people who consumed tobacco or cigarettes was reduced to 58 (48.3%), although this is a high figure for how harmful it is to the organism; however, the effect of the strategy on this risk factor for cardiovascular diseases is evident.

On the other hand, at the initial moments, there were 76 inhabitants (63.6%) who consumed alcohol three or more times in high proportions, which greatly affected the human organism. After receiving the educational actions, this risk factor was reduced, since after the strategy was applied, it dropped to 49 for 40.8%, which makes it evident that when educational actions are carried out systematically and with a scientific basis, it is possible to sensitize and educate people about the harmfulness of this substance for the human organism.

Table 2. Results of question 1 of the survey.

Answer	Before	After
Yes	29 (20%)	113 (94,1%)
No	96 (80%)	12 (9,6%)

Indicator knowledge of proper nutrition

The results of question 2 of the survey applied to the members of the sample, where 11 of the inhabitants, for 9.1% of the sample under study, stated that they had a balanced diet and exemplified the amount of food intake per day, with the nutrients in their diet. However, the majority (84.1%) reported eating street food such as hamburgers, hot dogs, pizzas and KFT chicken and other dishes with high fat content, as well as not having a stable schedule to do so, since they depend on their work schedule. On the other hand, 8 inhabitants (6.8%) left the survey blank.

A very different result was observed after the educational intervention strategy was applied. A total of 111 villagers, or 92.5% of the sample, reported consuming healthy and balanced nutrients. In addition, most of them explained how important the research was to change their eating style. This shows the effectiveness of the proposal after its application.

The exposed results make evident that the population involved in the research, after interacting with the actions and activities of the intervention strategy, were educated about the measures for the prevention of cardiovascular diseases. This is significant since they contribute to a healthy and active lifestyle.

Table 3. Results of question 2 of the survey.

Answer	Before	After
Yes	11 (9,1%)	111 (92,5%)
No	114 (91,2%)	14 (11,2%)

Knowledge of the benefits of physical activity indicator

The results of this indicator belong to question 3 of the survey and show that at the beginning of the study, before applying the strategy, there was a group of people who did not know the benefits of systematic physical activity, as reflected in the fact that 99 (99 for 82.5% of the sample under study) indicated the option no. The rest, only 21 for 17.5%, said yes. While the rest, only 21, or 17.5%, said yes. In the answer that they were asked to argue, the majority stated that physical activity is performed by athletes, an issue that makes evident the lack of knowledge that they present about this content.

After the educational actions of the strategy were applied, there was an increase, since 117 for 97.5% of the sample stated that they knew the benefits of physical activity. In addition, 100% of those involved in the research stated that during the intervention process, they had changed their opinion about physical activity and now understand that it is very beneficial for health in general and for cardiovascular diseases in particular.

Table 4. Results of question 3 of the survey.

Answer	Before	After
Yes	99 (82,5%)	117 (97,5%)
No	21 (17,5%)	8 (6,5%)

By way of summary, this dimension shows that urban dwellers show an adequate level of knowledge on the prevention of cardiovascular diseases in urban communities, based on physical culture, which was acquired from the media and scientific and specialized literature, which served as a basis for the actions and activities of the strategy presented for this purpose.

The statistical comparison using the nonparametric test of Mc. Nemar, processed by the statistical package SPSS version 20.0 for Windows, corroborated the existence of very significant changes in each one of the indicators of the dimensions of the study variable by obtaining in all cases that the calculated probability was lower than the prefixed probability ($p=0.00 < 0.05$). This result evidences that the prevention of cardiovascular diseases in the process of physical culture for the urban communities of the department of Cundinamarca of Colombia in the selected sample changes significantly in the second moment of the research.

Discussion

In agreement with the idea Tuomilihto et al. [15] point out that it has been demonstrated that physical exercise, together with proper diet, can prevent up to 58% of the incidence of these diseases, in addition, they benefit especially, with a regular program of aerobic exercise. On these arguments, the results through orientation workshops individually prepared the actors involved to carry out the activity at home.

The results of the research by Delgado and Acuña [16] reveal that it is not precisely defined what the duration of the exercise session should be to reduce cardiovascular risk; although time does not seem to have an influence. However, in this research, it was shown that in one year with systematic physical activity and with three weekly frequencies some cardiovascular indexes are improved.

According to the criteria of Planas [17] in the relationship of the effects of exercise on cardiovascular risk factors, poor physical fitness seems to be associated with a determining factor in these diseases. Individuals with poor physical fitness were 3-6 times more likely to develop these cardiovascular risk factors than those with good physical fitness. That is why in the present study we worked three times a week and the results are evident in the level of significance derived from this research.

According to the study conducted by Dupotey et al. [18] where they reflected on which exercises to apply for the prevention of cardiovascular diseases, they evaluated the local and general effects of physical activity on this system. This study was the basis for the results presented today.

The work offered urban dwellers and social managers a tool to contribute to the awareness of all the members of the community, from different interventions approved in the normative documents of Colombia; to achieve an adequate prevention of cardiovascular diseases.

4. Conclusion

The systematization developed pieces of evidence of insufficiencies related to the integration of the promotion and awareness of the actors on healthy lifestyles, the creation of healthy environments in different community spaces, the development of educational physical activities, and the prevention of cardiovascular diseases in the urban communities of the department of Cundinamarca, Colombia.

The analysis and interpretation of the results, through expert consultation, confirmed the theoretical assessment, while application in practice, demonstrated the effectiveness of the educational intervention strategy for the prevention of cardiovascular diseases from physical culture for urban communities in the department of Cundinamarca, Colombia. Based on the results of the application of neutrosophy, it is necessary the timely intervention in the student population with tools that promote the prevention of cardiovascular diseases from the physical culture for urban communities in the department of Cundinamarca, Colombia.

For future work, it is suggested to deepen the application of neutrosophic methods to assess and address the complexity and uncertainties involved in promoting cardiovascular disease prevention. This approach could be extended to other demographic groups within Cundinamarca, including vulnerable populations, to enhance the understanding of different variables affecting health outcomes. Furthermore, incorporating neutrosophic tools into community health programs could improve decision-making processes, allowing for more adaptable and inclusive educational strategies in the promotion of healthy lifestyles.

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