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SUMARIO ● SUMMARY ●RESUMO

Editorial

From the Editorial Board of *MLS Health and Nutrition Research*, we proudly celebrate the publication of the second issue of our third year as a means of scientific dissemination in the field of health, nutrition and food. We would like to express our most sincere gratitude to the authors who have placed their trust in our journal, whose valuable contributions have been essential to consolidate our presence and continue promoting the transfer of knowledge.

In this issue, we present innovative and relevant research that addresses fundamental issues for the scientific community:

The first article deals with the *"Effect of meal frequency and meal timing on overweight and obesity".* In recent years, there has been a growing interest in knowing what factors affect weight gain or weight loss in the daily diet, which has led to the emergence of chrononutrition. This issue is increasingly relevant as a possible explanation for weight gain in adults. The aim of this article was to gather scientific evidence to evaluate the effect of the timing and frequency of intake on overweight and obesity in adults, based on a literature review including 35 articles from PubMed and Google Scholar databases.

From the field of public health, the article *"Assessment of infant feeding knowledge among mothers in the cabinda integrated"* is presented. This study highlights the crucial role of mothers' nutritional knowledge in the fight against child malnutrition. A total of 372 mothers of children under five years of age were evaluated for four months, revealing that area of residence and income have a greater influence on nutritional knowledge than schooling or age.

In the following article, *"Effect and comparison of the ketogenic, mediterranean and low glycemic index in the treatment of ovarian syndrome polycystic (PCOS),"* the effects of three dietary patterns in women with PCOS are reviewed. This study shows that the ketogenic diet is effective in the short term, but difficult to maintain; the Mediterranean diet offers sustainability and overall benefits; and the low glycemic index diet improves hormonal and lipid profiles. It is concluded that a combination of these patterns could optimize results according to individual needs.

From the field of clinical nutrition, the article *"Perception of the risk of suffering type 2 diabetes mellitus in young and adults aged 20-39 in the department of Guatemala"* explores the perception of risk in adults aged 20-39 years. The results show that 45% of the participants feel at risk of developing diabetes, the main risk factors being family history,

overweight and lack of exercise. This study underscores the need for preventive policies and increased health education.

The following article, *"Macronutrient intake distribution according to circadian rhythms,"* discusses the relationship between circadian rhythms and optimal macronutrient intake to optimize weight loss. Based on a literature review of 14 recent articles, we explore how aligning nutrition with biological rhythms can improve metabolic outcomes.

Finally, *"Influence of nutrition on the improvement of sport performance in speed swimming"* highlights how nutrition can enhance performance in this discipline. This article proposes a specific dietary guide for sprint swimmers, developed after a review of recent scientific literature, with the aim of helping these athletes reach their maximum potential.

With this edition, we reaffirm our commitment to be a bridge between research and practice in health and nutrition. We invite the scientific community to continue to rely on our journal to share their findings and enrich the collective knowledge.

Dr. Iñaki Elío Pascual
Chief Editor
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Effect of meal frequency and meal timing on overweight and obesity

Efecto que tienen la frecuencia y horarios de las ingestas sobre el sobrepeso y obesidad

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ABSTRACT

In recent years, there has been an increased interest in understanding which factors, beyond caloric intake, related to daily eating habits affect weight gain or the difficulty in losing weight, leading to the emergence of chrononutrition. This topic is becoming increasingly relevant as a potential explanation for weight gain in adults. The objective of this article is to compile scientific evidence to evaluate the effect of meal timing and frequency on overweight and obesity in adults. This is a literature review, using 35 articles, with PubMed and Google Scholar being the main databases used. The study results indicate that having a higher number of meals per day is associated with a lower BMI and better anthropometric outcomes. Additionally, following a morning meal schedule promotes greater weight loss and is also associated with a lower BMI. Moreover, studies reveal that a morning meal schedule improves hormonal signals, exerting control over intake signals. In conclusion, more evidence is needed to confirm the results found, with more studies of higher quality. Nevertheless, the evidence suggests that having more meals, earlier in the day, with a higher caloric load in the morning, could be key for improvements in anthropometric measures, weight, and BMI.

Keywords:
chrononutrition, intake frequency, meal timing, circadian rhythms.

RESUMEN

En los últimos años, ha incrementado el interés por conocer qué condicionantes acerca de la alimentación diaria afectan al incremento o difícil disminución de peso, habiendo surgido así la crononutrición. Este tema es cada vez de más relevancia como búsqueda de una posible

Palabras clave:

crononutrición, frecuencia de ingesta, horario de ingesta, ritmos circadianos.

explicación al aumento de peso en adultos. El objetivo de este artículo es recopilar evidencia científica para evaluar el efecto que tiene el momento de ingesta y la frecuencia de las tomas sobre el sobrepeso y la obesidad en adultos. Se trata de una revisión bibliográfica, para la que se usaron 35 artículos, siendo Pubmed y Google Académico las principales bases de datos utilizadas. Los resultados de los estudios señalan que realizar un mayor número de ingestas en el día se relaciona con menor IMC y mejores resultados antropométricos; además de que llevar a cabo un horario matutino de comidas promueve mayores pérdidas de peso y se relaciona igualmente con un menor IMC. Además, estudios revelan que el horario matutino mejora las señales hormonales, ejerciendo un control sobre las señales de ingesta. Como conclusión, sería necesaria más evidencia para poder confirmar los resultados encontrados. No obstante, la evidencia apunta a que realizar más ingestas, en un horario temprano, y con una mayor carga calórica en la mañana, podrían ser claves para mejoras antropométricas, del peso y del IMC.

Introduction

Obesity is known to be an important risk factor for certain diseases such as type 2 diabetes mellitus, arterial hypertension, cardiovascular risk or certain types of cancer, in addition to producing a notable decrease in the quality of life of those who suffer from it (1).

For decades, this condition has been increasingly prevalent, mainly in developed Western countries, and is now a real public health problem. Thus, whereas 40 years ago the prevalence was 1% in childhood, 3% in men and 6% in women, today it is around 6-8%, 6% and 15%, respectively, mainly due to lifestyle changes (2).

The usual treatments have focused on lifestyle interventions, which may interfere with diet and physical activity. Diet is an essential factor in weight control in people who are overweight or obese, and until now there have been several main conditioning factors to combat it: the reduction of the total daily caloric intake and the importance of the macronutrients in the diet (3). In recent years, there has been an increased interest in learning about other determinants of the daily diet that affect to some extent the increase or difficult decrease in weight, and thus chrononutrition has emerged (4).

The term chrononutrition refers to the relationship between biological rhythms and food and nutrition. Circadian rhythms influence food intake and fasting through the internal biological clock; conversely, disordered eating can disrupt internal clocks. Thus, chrononutrition encompasses three dimensions of eating behavior: frequency, regularity and timing. There is increasing evidence and of higher quality that chrononutrition, taking into account any of its dimensions, would have an impact on the metabolic health of individuals, and ultimately on the well-being and general health of the subjects. Thus, the relationship of circadian rhythms and diet to unwanted weight gain and, ultimately, to overweight and obesity is being studied.

Method

In this literature review, a number of papers have been examined, including different articles that analyze the relationship between the number of daily intakes and anthropometry, as well as the time of day when intakes are taken and anthropometry (weight, BMI, waist-hip ratio...).

The search for articles and other publications related to the developed topic began on February 20, 2024 and ended on April 30, 2024. In order to carry out this study, an exhaustive search of multiple publications, all of them in digital format, has been carried out in different databases. The databases that were used to start the search were:

- Pubmed: the following filters were established: free full text, maximum 5 years old (2019-2024) and written in British English. For the search for studies, the keywords used for the search were, in MeSH terms:
    - Meal frequency AND Obesity: a total of 69 studies were found, of which 1 was used due to its relevance and for meeting the aforementioned inclusion criteria.
    - Meal frequency AND overweight: a total of 57 studies were found, of which 1 was used because of its relevance and because it met the inclusion criteria mentioned.
    - Meal timing AND Obesity or overweight: a total of 23 studies were found, of which 3 were used because of their relevance and because they met the inclusion criteria mentioned above.
    - Chrononutrition AND body composition: a total of 2 studies were found, of which 1 was used because of its relevance and because it met the inclusion criteria mentioned.

  For the article search, in general, for the theoretical framework, the keywords used were:
    - Chrononutrition: a total of 163 articles were found, of which 2 were used because of their relevance and because they met the inclusion criteria mentioned above.
    - Chronobiology: a total of 1556 articles were found, of which 6 were used because of their relevance and because they met the inclusion criteria mentioned above.
    - Obesity risk factors: a total of 23492 articles were found, of which 8 were used because of their relevance and because they met the inclusion criteria mentioned.
    - Obesity epidemiology: a total of 28437 articles were found, of which 3 were used because of their relevance and because they met the inclusion criteria mentioned.
    - Circadian rhythms: a total of 8170 articles were found, of which 3 were used due to their relevance and because they met the aforementioned inclusion criteria.
    - Circadian rhythms and obesity: a total of 570 articles were found, of which 3 were used because of their relevance and because they met the inclusion criteria mentioned.

- Google Scholar: a seniority of 5 years (from 2019) was established as a filter. The keywords used for the search were:
    - Meal timing and obesity / overweight: a total of 17,000 articles were found of which 4 studies were used due to their relevance and for meeting the inclusion criteria mentioned above.

Finally, 35 articles were used for the review.

Results

Most of the studies reviewed agree that the time of day and frequency of intakes could have an effect on multiple parameters, including body composition and anthropometry, and therefore on obesity or overweight.

Analyzing the studies that refer to the frequency of intakes, two of them (26,27) have a direct bearing on the issue, while the other (28) evaluates a fasting method that indirectly implies a lower number of daily intakes. Both the Dote-Montero et al. (26) and Ha and Song (27) conclude that the more meals eaten, the lower the obesity and BMI; however, Dote-Montero et al. (26) only found this relationship in the case of women, while that of Ha and Song (27) in both sexes. This could be due to the fact that the first (26) has 118 participants, of which practically ⅔ correspond to women, and therefore it is easier to find a relationship than in the case of men who only have 36 participants. In addition, this is a cross-sectional study, so it is not able to establish causal relationships and the information provided may not be accurate. Although Ha and Song's (27) agrees that increasing the number of intakes is related to a reduction in obesity, it indicates that it would be from 8 or more intakes per day, as compared to 4 or less, which is out of the ordinary and unrealistic.

Wilkinson et al. (28) conclude that fasting, limiting the intake until 14h, reduces the weight of the participants by up to 3%; however, they only have 19 participants, which is a very limited number of subjects. Moreover, it does not directly evaluate the number of intakes nor does it provide any specific data in this regard, but only indicates that fewer intakes are made, so the results are not very specific and could be unreliable since they have been carried out with such a small sample.

Likewise, the studies by Ha and Song (27) and Dote-Montero et al. (26) are based on self-reported questionnaires of the "24-hour dietary record" type, specifically for a single day; therefore, even if the participants tried to include their usual diet in the record, there could be losses of information, or a non-representative diet because it is a single day.

It should be taken into account that the study by Wilkinson et al (28) is the only one that includes participants with metabolic syndrome and obesity, while the others (26,27) include healthy participants, which could explain the differences in the results obtained (so that in healthy subjects increasing the number of intakes is related to better anthropometric results, and in overweight/obese subjects these intakes should be limited).

However, the number of recent studies found on the relationship between the number of intakes and weight loss or gain are scarce, and have numerous limitations such as few participants (28), not being able to establish causal relationships (26) or lack of information (26-28).

Table 1. Studies relating the frequency of ingestion to influential parameters on body weight

Author, year	Type of study	Subjects/groups	Main results	Conclusions
Dote-Montero et al., 2023(26)	Cross-sectional study	118 young adults (82 women and 36 men) participated Age = 22 ± 2 years BMI = 25,1 ± 4,6 kg/m^2	Meal timing is not related to anthropometry or body composition. Skipping breakfast, and thus having a longer feeding window and fewer meals, is associated with poorer body composition in women and higher BMI.	It was concluded that eating more meals and not skipping breakfast is related to less obesity and BMI in women.
Ha and Song, 2019(27)	Cross-sectional study	Among 27220 initial participants, 14279 subjects (8425 women and 5854 men) were finally included in the analysis. Mean age = 41.1 years in men; 41.7 years in women.	Men with more daily intakes (8 per day) have less abdominal obesity than men with approximately 4 intakes per day. In addition, women who eat in the morning have less abdominal obesity, and men who eat in the evening have more metabolic abnormalities (including obesity).	It was concluded that having a greater number of intakes reduces metabolic abnormalities, including obesity.
Wilkinson et al., 2020(28)	Clinical trial	Initially, 35 subjects participated, of whom 19 (13 men and 6 women) with metabolic syndrome were finally included. Average age = 59 ± 11.14 years	The participants' body weight was reduced by about 3%.	It was concluded that limiting intake to fewer meals per day was significantly associated with weight loss and cardiometabolic improvements.

Regarding the relationship between the timing of daily intakes and body weight, a greater number of recent studies have been found. Most of these agree that an early feeding schedule is associated with either greater weight loss or lower weight, BMI or other parameters (such as hunger signals) than a late feeding schedule (27,29-34). However, other studies deny that eating at certain times is associated with greater weight loss or lower BMI (26,35). However, it is necessary to go deeper and analyze how each of them has obtained their results and why they are different.

Several of these studies are randomized controlled trials, in which participants are randomly divided into groups that follow a diurnal or delayed diet for a given period of time, in order to ultimately evaluate the body changes produced in each group and compare them with each other (29,30). However, in one of them, the early and late groups differed only by the time of the beginning of intake, resulting in a much higher weight loss in the early group compared to the late group (and taking into account that physical activity, caloric intake and macronutrient intake were the same in both groups) (29). In the other study, the intake of the early and late groups is limited to specific schedules (early intake from 8-19h and late intake from 12-23h), but also very controlled in terms of caloric and macronutrient intake and physical activity. Similarly, body weight at the end of the study was lower in the early group than in the late group, and other parameters such as fat oxidation and insulin sensitivity improved (30).

However, this latest study (30) suggests that hormones are not affected and therefore we consider that they are not responsible for these differences. One possible explanation that early eating leads to improvements in body weight is the first meal of the day, which alone would not improve weight loss, but the habit of eating early increases the likelihood of weight loss. It should be noted that one of these studies (29) was conducted in overweight/obese adults and the other (30) in normal-weight adults. But these studies only control for the timing of intake and not the intake itself 27 (29,30).

The study by Ruddick-Collins et al. (35) followed the same line as the previous ones and divided the participants into two groups, but in this case the schedule remained the same in both and what varied was the caloric load in each intake (more loaded in the first intake or more loaded in the last), similar to that of Gu et al. (34) in which two groups had four meals, but the last two were different in caloric load. In the first of these (35), weight loss was practically identical, with no significant differences, but a lower sensation of hunger, thirst or desire to eat was observed in the diet loaded in the morning compared to the one loaded in the evening (explained by hormonal changes and slower gastric emptying). The other (34), on the other hand, did not directly evaluate the effect on obesity, but did conclude that the heavier diet at night induced an anabolic state during sleep that favored the increase in lipid storage, ultimately promoting obesity. However, this last study had only 20 healthy, normal-weight participants, so the conclusions are controversial and more studies should be conducted with a larger number of participants. Even so, the results are likely to be reliable as they have been performed through a laboratory in a highly controlled manner, eliminating possible biases. Similarly, that of Ruddick-Collins et al. (35) was carried out with only 30 participants, but in this case with overweight or obesity, and presented possible biases due to non-compliance with what was proposed by the participants (there was no rigorous control).

Along the same lines as the above, other studies have focused on evaluating hunger or satiety signals, food cravings, as well as hormonal responses to eating at

certain times, as possible explanations for unwanted weight gain (31,32). In their research, Vojovic et al. (31) studied how schedules affect the control of intake, energy expenditure and adipose tissue in overweight or obese subjects, obtaining as results that eating late (or having a late schedule of intakes) produced less satiety and more hunger; in addition to a significant reduction in energy expenditure compared to an early schedule. This study went a step further and evaluated the regulation of adipose tissue, observing a reduction in lipolysis and an increase in lipogenesis. This was also carried out through a biopsy, which is associated with reliable results. However, it was composed of only 16 participants. Another similar study (32) also focused on the signals after late-hour ingestion, but in this case it went a step further and differentiated the participants into two groups according to their chronotype (assessed by a questionnaire), and both groups performed both early and late hours. The results regarding late hours were consistent with the previous study (31), being related to less appetite and more satiety. In addition, it was concluded that early chronotype was related to lower BMI and greater satiety after meals. In this case, the study by Beaulieu et al. (32) was composed of more participants and healthy subjects, so we can conclude that in both healthy and overweight or obese subjects the earlier schedule would improve intake signals and hormonal responses; and regarding the chronotype more studies would be needed.

Two studies (26,27) focused on assessing anthropometric and body composition outcome through 24-hour reminders that documented the participants, and thus their meals and the exact times at which they were eaten were known. With this information, a series of conclusions were drawn. In this case, while the study by Ha and Song (27) showed that eating more at night than in the morning influences the development of metabolic syndrome, in addition to the fact that eating at night is related to higher weight and worse body composition in men. However, Dote-Montero et al (26) found no association between the schedule and body composition and anthropometry. However, it should be taken into account that both are cross-sectional studies, which prevents the establishment of causal relationships (cause-consequence), in addition to the fact that the 24-hour reminders in both studies were for a single day, which may generate certain information biases (non-representativeness of the general intake, forgetfulness, etc.).

It is surprising that the study by Ha and Song (27) shows an association between nocturnal intake and worse anthropometry only in men. One possible explanation is that men tend to be greater night eaters than women, and in addition to foods with a higher caloric load, it could even be associated with alcoholism and smoking.

However, both studies (26,27) are rather incomplete and leave a lot of information unresolved, so more should be done to reach more reliable and conclusive results.

Finally, Barring and Beresfod (33), in their randomized controlled trial, focused on how snacking promoted obesogenic behaviors, and how it affected the timing of snacking. The results suggest, like others cited above, that more morning and even midday snacking is associated with lower BMI and obesogenic behavior compared to evening snacking. However, the composition of these snacks (which in the evening tend to be higher in calories than those in the morning, which are more composed of fruit) was not evaluated. That is, it could be that the relationship was not directly due to the pecks, but to the composition of the pecks.

It should be noted that several of these studies take into account "early" and "late" schedules, which vary greatly from one study to another, depending on the habits and customs of the countries of origin of the studies. Thus, according to each study it is

established that "morning feeding" is at 5-9 hours (27), 8-10 hours (32) or 7-8 hours (35), and "evening feeding" at 18-21 hours (27), 16-18 hours (32); as well as "daytime feeding" from 8-19 hours and "delayed feeding" from 12-23 hours in the study of Allison et al. (30); or the study by Barrington and Beresford (33) that establishes that "snacking in the evening" is if it is done after 4:30 pm.

Table 2. Studies relating the timing of intakes to influential parameters on body weight

Author, year	Type of study	Subjects/groups	Main results	Conclusions
Hatanaka et al., 2022(29)	Randomized controlled trial	Ninety-seven adults (51 men and 46 women) were studied, of whom 85 (43 men and 42 women) were included Age = 47.6 ± 8.3 years BMI = 25.4 ± 3.7 kg/m2	Of the relationship between pre-intervention meal timing and weight change, only the start of the feeding window was positively correlated with the rate of weight change in both sexes. The rate of weight change was -3.8 ± 2.7% in the early group and -2.2 ± 2.5% in the late group.	The rate of weight loss in the early group was significantly higher than in the late group. It was concluded that early feeding window initiation was associated with weight loss.
Dote-Montero et al., 2023(26)	Cross-sectional study	118 young adults (82 women and 36 men) participated Age = 22 ± 2 years BMI = 25.1 ± 4,6 kg/m^2	Meal timing is not related to anthropometry or body composition. Skipping breakfast, and thus having a longer feeding window and fewer meals, is associated with poorer body composition in women and higher BMI.	It was concluded that there is no significant relationship between meal timing and anthropometry and body composition.
Barrington and Beresford et al., 2019(33)	Randomized controlled trial	Employees from 34 different workplaces in Seattle. Initially, 3054 subjects participated, but during follow-up, 1151 subjects (of different sexes, BMI, cc, ethnicity) remained Average age = 43 years	Subjects with more morning snacking had lower BMI and higher fruit and vegetable intake, as did those with more midday snacking. However, those who snack more in the evening have a higher BMI and obesogenic dietary index.	The authors concluded that snacking is related to obesogenic behaviors, mainly if done at night (higher BMI, cc, less fruit and vegetable intake)
Wilkinson et al.,	Clinical trial	Initially, 35 subjects participated, of whom 19	The participants' body weight was reduced by about 3%.	It was concluded that limiting intake after 14H was significantly related to weight loss

2020(28)		(13 men and 6 women), all with metabolic syndrome, were included. Average age = 59 ± 11.14 years		and cardiometabolic improvements.
Allison et al., 2021(30)	Randomized crossover trial	29 initial participants, of which 12 completed the study and provided eligible data (7 males and 5 females) Age = 26.3 ± 3.4 years BMI = 21.9 ± 1.7 kg/m2	-Body weight is lower in diurnal than in retarded individuals -Resting energy expenditure and respiratory quotient is lower in diurnal and higher in tardive, which implies lower fat oxidation in tardive -Total cholesterol and triglycerides are higher in late bloomers (but HDL and LDL improve) -There is a slight increase in adiponectin in tardigrade (improvement) -Fasting glucose and insulin, and insulin resistance are lower in diurnal -Regarding melatonin, cortisol, leptin, ghrelin and glucose, there are no significant differences between groups	It was concluded that eating at earlier hours leads to improvements in weight, insulin resistance, fat oxidation, fasting glucose, insulin, triglycerides and total cholesterol. However, HDL and LDL, and adiponectin, improved in the late group. Hormones are not affected. Therefore, the authors conclude that late feeding has adverse effects on weight and metabolic parameters in general, independent of energy intake, PA or sleep.
Ruddick-Collins et al., 2022(35)	Randomized controlled trial	30 obese/overweight subjects (16 males and 14 females) Average age = 50.9 +- 2.1 years BMI = 32,5 +- 0,7 kg/m2	-Almost identical weight losses (Morning D.-3.3 kg; Late D.-3.38 kg) -D.Morning scored significantly lower in hunger, food craving and thirst → more hormonal changes (hunger suppression, ghrelin and satiety hormone increase), and slower gastric emptying than D.Late) -No alteration of energy expenditure (PA and intake being the same in both groups)	Study concludes that calorie utilization does not vary throughout the day and that it does not matter at what time of the day you eat more or fewer calories → there will not be more loss of calories from eating larger meals in the morning as suggested by previous studies

Vujović et al., 2022(31)	Randomized controlled trial	16 participants (11 men and 5 women) Age = 37.3 ± 2.8 years BMI = 28.7 ± 0.6 kg/m2	-Regarding hunger/appetite, measured on the VAS scale, late intake showed a higher hunger score (> 50) compared to early intake (10-20) -Hormones (leptin, ghrelin and ghrelin:leptin ratio) were studied every hour of each day: leptin decreased 6% and ghrelin:leptin ratio increased 12%; during wakefulness, leptin decreased 16% and ghrelin:leptin ratio increased 34%; and during sleep, leptin increased 10% and ghrelin and ghrelin:leptin ratio decreased 13 and 18%, respectively -GE decreased significantly in late intake (5.03%) with respect to early intake (during wakefulness) and body temperature (BT) decreased during sleep -Late ingestion increased activity of lipogenesis genes and decreased activity of genes responsible for lipolysis	Eating late consistently alters the regulatory functions of intake, energy expenditure and body composition, favoring weight gain and body fat.
Gu et al., 2020(34)	Randomized controlled trial	20 healthy subjects (10 males and 10 females) Age = 26.0 ± 0.6 years BMI = 23.2 ± 0.7 kg/m2	-Peak glucose max after dinner: higher GT (150.3 +- 5.6 mg/dL) than GR (127.0 +- 4.5 mg/dL) after breakfast: further increase of insulin and glucose in GT mean blood glucose significantly higher in GT (105.8 +- 2.3 mg/dL) than in GR (99.8 +- 2 mg/dL) -TG in GR peak max 1h after dinner, but does not rise after dinner in peak GT max 1 hour after snack, still rising	It was concluded that the increased caloric load late in the day causes an anabolic state that favors lipid storage, so that in a chronic form it may favor the development of obesity.

			after dinner -Lower AG oxidation at 4h in GT (74.5+-5.7%) than in GR (84.5 +-5.2%) -Higher mean cortisol in GT (11.4 +- 0.6 microg/dL) than GR (10.8 +- 0.5 microg/dL)	
Beaulieu et al., 2020 (32)	Laboratory study	50 participants, including 44 adults between the ages of 18 and 25 years old	Eating early meals reduced appetite, increasing satiety. Subjects with early chronotype had lower BMI than those with late chronotype, as well as a greater feeling of satiety after meals.	It is concluded that early meals (8-10H) result in lower post-meal appetite and greater satiety, as well as less desire to eat fatty foods. In addition, it is also concluded that the early chronotype is related to lower BMI compared to the late chronotype, greater satiety after meals and lower desire to eat fatty foods.

Discussion and conclusions

After the analysis carried out in this work, it is important to emphasize that there is still much to investigate and to know in order to reach reliable conclusions about how much to eat and at what times of the day to achieve effective weight loss (or to avoid unwanted weight gain).

So far and with the results of the studies analyzed, it could be considered that having a greater number of daily intakes is recommended to obtain improvements in the weight and/or BMI of the subjects, compared to having fewer intakes. But it is not clear what number of intakes we are talking about, since the present studies are not very concise and do not reach the same conclusions as to the exact number of daily intakes.

An early schedule could also be considered for successful weight loss in cases of overweight or obesity, and for better anthropometric results (BMI, waist-to-hip ratio, body fat). From the studies analyzed, it could be affirmed that the intake signals (hunger and satiety) and the desire to eat obtain better results when intakes are made at early versus late times. However, it is not only the timing of intakes that should be taken into account, but also the caloric load of those intakes, as some studies suggest that a higher late caloric load promotes a state of overweight/obesity, while a higher morning caloric load promotes weight loss.

Finally, although the evidence is very limited, the studies carried out in relation to the chronotype of the subjects suggest that whatever the chronotype of each subject, an early meal schedule is the best option for anthropometric improvements. However, more studies are still needed to complement and confirm the current evidence, as it is still limited and scarce.

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Assessment of infant feeding knowledge among mothers in the cabinda integrated

Evaluación del conocimiento sobre alimentación infantil de madres del proyecto integrado de Cabinda

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ABSTRACT

Mothers' nutritional knowledge plays a critical role in the fight against childhood malnutrition, particularly regarding infant feeding practices. Inadequate knowledge is linked to high neonatal mortality rates. Conversely, mothers with better knowledge can contribute to improved feeding practices, potentially reducing the prevalence of this disease and its negative consequences. This study aimed to assess the level of nutritional knowledge among mothers participating in the Cabinda Integrated Project. Employing a cross-sectional quantitative design, the study enrolled 372 mothers of children under five during a four-month period (January-April 2023). A probability sampling technique with a Raosoft sample size calculator ensured representativeness. Data collection utilized two questionnaires: the Sociodemographic Variables Questionnaire and the Questionnaire for Evaluating Parents' Knowledge on Infant Complementary Feeding. Chi-square tests ($p < 0.05$) analyzed relationships between variables. Analysis revealed that a majority (51.34%) of mothers demonstrated adequate nutritional knowledge. Interestingly, a statistically significant disparity emerged between income, area of residence, and knowledge. Mothers from lower socioeconomic backgrounds displayed higher knowledge (60.87%) compared to those with income ($p = 0.0001$). Similarly, mothers in rural areas (75.80%) exhibited superior knowledge compared to urban counterparts (33.49%) ($p = 0.000$). Notably, no significant association was found between nutritional knowledge and educational attainment or age. The study concludes that nearly half of the mothers possess adequate nutritional knowledge. However, income and area of residence appear to have a stronger influence than education or age. This suggests that solely focusing on education and age may be insufficient to improve mothers' nutritional knowledge.

Palabras clave:
Proyecto Integrado de Cabinda, desnutrición infantil, prácticas de alimentación infantil, mortalidad

RESUMEN

El conocimiento nutricional de las madres desempeña un papel fundamental en la lucha contra la desnutrición infantil, especialmente en lo que respecta a las prácticas de alimentación de los bebés. La falta de conocimiento está asociada a altas tasas de mortalidad neonatal. Por otro lado, las madres con mayor conocimiento pueden contribuir a

neonatal, conocimiento nutricional, madres.	mejorar las prácticas alimentarias, reduciendo potencialmente la prevalencia de esta enfermedad y sus consecuencias negativas. Este estudio tuvo como objetivo evaluar el nivel de conocimiento nutricional entre las madres participantes del Proyecto Integrado de Cabinda. Utilizando un diseño transversal cuantitativo, el estudio involucró a 372 madres de niños menores de cinco años durante un período de cuatro meses (enero a abril de 2023). Una técnica de muestreo probabilístico con una calculadora de tamaño muestral Raosoft garantizó la representatividad. La recolección de datos utilizó dos cuestionarios: el Cuestionario de Variables Sociodemográficas y el Cuestionario de Evaluación del Conocimiento de los Padres sobre Alimentación Complementaria Infantil. Las pruebas de chi-cuadrado ($p < 0,05$) analizaron las relaciones entre las variables. El análisis reveló que la mayoría (51,34%) de las madres demostró un conocimiento nutricional adecuado. Curiosamente, surgió una disparidad estadísticamente significativa entre los ingresos, el área de residencia y el conocimiento. Las madres de origen socioeconómico más bajo demostraron un mayor conocimiento (60,87%) en comparación con las madres de mayor ingreso ($p = 0,0001$). De la misma manera, las madres en áreas rurales (75,80%) demostraron un conocimiento superior en comparación con las madres urbanas (33,49%) ($p = 0,0001$). Cabe destacar que no se encontró ninguna asociación significativa entre el conocimiento nutricional y el nivel educativo o la edad. El estudio concluye que casi la mitad de las madres posee un conocimiento nutricional adecuado. Sin embargo, los ingresos y el área de residencia parecen tener una influencia más fuerte que la escolaridad o la edad. Esto sugiere que enfocarse solo en la escolaridad y la edad puede ser insuficiente para mejorar el conocimiento nutricional de las madres.

Introduction

The early years of life are a critical window for shaping a child's overall well-being. From the moment they enter the world, children absorb information and behav-iors from their environment, particularly their mothers. Mothers play a central role in nurturing and caring for their children, especially when it comes to nutrition. The foods a child is introduced to early on establish patterns that can influence their health for life.

Equipping mothers with a strong understanding of infant and young child nutri-tion empowers them to make informed dietary decisions. Studies have shown that mothers with a good grasp of nutrition can significantly reduce the risk of childhood illnesses like malnutrition, anemia, and stunted growth. Conversely, inadequate knowledge can have detrimental consequences.

The benefits of well-informed maternal dietary practices are far-reaching. Stud-ies, such as the one conducted by (1) have shown that mothers with a strong under-standing of nutrition can significantly reduce the risk of a multitude of childhood health challenges in their children. These challenges include malnutrition (a condition where a child doesn't get enough nutrients to be healthy), anemia (a deficiency in red blood cells that can cause fatigue), stunted growth (where a child's height or weight is lower than expected for their age), common childhood illnesses, and even premature death.

Unfortunately, these very issues – malnutrition, anemia, stunted growth, and preventable childhood illnesses – are prevalent not only in Angola but also throughout the world. This underscores the critical need to invest in programs that empower moth-ers with the knowledge and tools they need to nourish their children and build a founda-tion for a healthier future. By focusing on Cabinda Province, Angola, we can begin to make a real difference in the lives of mothers and their children, paving the way for a generation where all children have the opportunity to thrive.

According to a study by (2) and published in The Lancet, the global prevalence of severe acute malnutrition (SAM) in children under five reached an alarming 14.3 mil-lion in 2019. This concerning finding highlights the magnitude of SAM as a global public health problem with serious consequences for child morbidity and mortality. In Angola, the situation is particularly alarming, with a staggering 38% of children under five ex-periencing chronic malnutrition (3).

Another study emphasizes the urgency of intervention, warning that without immediate action, 56 million children under five could perish by 2030 globally (4).

Multiple factors contribute to the rise of malnutrition in its various forms. Poverty, dis-eases, natural disasters, and limitations in food accessibility all play a role (5). Addition-ally, work, school, and neighborhood environments can influence dietary choices (5).

Beyond the immediate threats of child morbidity and mortality, the world faces a growing burden of chronic non-communicable diseases (NCDs) such as cancer, diabetes, cardiovascular diseases, chronic respiratory conditions, injuries, and mental health conditions (6). These diseases often manifest in adulthood, but a growing body of re-search suggests that poor dietary habits, behaviors, and cultural practices established during childhood and adolescence may lay the foundation for these problems (6). Nota-bly, NCDs account for approximately 74% of all deaths globally, with a disproportionate impact on individuals in poorer countries (6).

To the best of our knowledge, this is the first comprehensive investigation of its kind in Cabinda. The findings of this research will be instrumental in empowering the

nutrition specialists at World Vision Angola, who are responsible for implementing the Cabinda Integrated Project. This knowledge will equip them with a deeper understand-ing of the nutritional knowledge and dietary habits of mothers participating in the pro-ject. In turn, this understanding can inform the development and implementation of tar-geted interventions to improve child health outcomes in Cabinda.

This study aimed to assess the nutritional knowledge of mothers participating in the Cabinda Integrated Project.

Methods

Research Design

This is a non-experimental, descriptive cross-sectional study with a quantitative approach, conducted on a probabilistic sample of mothers from the Cabinda Integrated Project.

Population and Sample

From June 6, 2022, to March 2023, the Cabinda Integrated Project (CIP) served 11,077 mothers of the 35,778 children tracked throughout the province, representing the study universe.

A sample of 372 mothers of both malnourished and healthy children who agreed to provide verbal informed consent and permission to use their data was selected. Other caregivers and mothers who did not agree to provide informed consent were excluded.

To determine the sample size, the Raosoft sample calculator (7,8) was used. For this purpose, the adopted confidence level was 95%, the margin of error and response distribution were 5% and 50%, respectively.

Variables

In light of the problem presented and the objectives to be achieved in this re-search, the independent and dependent variables were measured. In this case, socio-demographic information constituted the independent variables: age, education, marital status, occupation, place of residence (urban and rural), religion and family income. On the other hand, the dependent variables were constituted by: mothers' knowledge of complementary feeding introduction, knowledge about types of complementary foods anda feeding method.

Measurement Instruments and Techniques

The Questionnaire for Evaluating Parents' Knowledge on Infant Complementary Feeding (QPAC) consists of 35 closed-ended questions grouped into 3 domains (com-plementary feeding introduction, types of complementary foods, and feeding method).

This questionnaire has been previously tested in other research to study parental knowledge about infant feeding (9).

A score of 1 (one) was assigned to each of the 35 questions for correct answers and 0 (zero) for incorrectly answered questions. Mothers' knowledge was classified into 4 categories adapted locally and based on the total percentage of correct answers:

insuffi-cient<30%, reasonable (≥30 and <50%), good (≥50 to <70%), very good (≥70 to 100%).

Sociodemographic data were collected using a sociodemographic variables ques-tionnaire (Q-SV) indicated by (10). Only caregiver variables (age, education, marital sta-tus, occupation, place of residence (urban and rural), religion, and family income) were used in this questionnaire.

Procedures

Data collection took place between January and March 2023, through face-to-face interviews conducted at the homes of participants from urban and rural areas of all municipalities in Cabinda Province (Cabinda, Cacongo, Buco-Zau, and Belize), mainly in areas where the Cabinda Integrated Project (CIP) is being implemented. All women with children under five years of age were invited to participate in the research, but only mothers who agreed to provide informed consent and permission to use their data were included.

The data collection process was carried out by Community Development and Health Agents trained for this purpose and by the main researcher. In addition to partic-ipating in data collection, the main researcher coordinated and supervised the entire data collection process.

Six main steps were necessary to carry out this research. Initially, the main re-searcher sought to identify data collection tools that would allow assessing mothers' nutritional knowledge about infant feeding, which were subsequently approved by the research supervisor.

Next, the main researcher built the questionnaires in Kobotoolbox.

The third step involved requesting research authorization from World Vision An-gola. This step culminated in the approval of data collection by the Ethics Committee of the Universidad Europea del Atlántico, as recorded in minute number CE-118.

After this process, the main researcher requested 10 of the 100 Community De-velopment and Health Agents from the Cabinda Integrated Project to participate in data collection from World Vision Angola.

The questionnaires were sent to the KoBoCollect on the smartphones (Android) of the Community Development and Health Agents in the fifth step, after the main re-searcher had trained the agents on the research objectives, goals, questionnaire ele-ments, and how to use KoBoCollect.

All questionnaire questions were explained clearly to all participants. Even so, whenever a mother did not understand the question, the interviewers provided guid-ance and explanations in a simpler way, both in the local language and in Portuguese.

60 minutes were set aside for the interview, but in practice, the conversations lasted between 30 and 40 minutes. The completed questions were sent to Kobotoolbox daily to facilitate the supervision.

The final step was the preparation of a report, statistical analysis, and data pro-cessing by the main researcher with the assistance of the supervisor.

Data Analysis

The data was collected using KoboToolbox software and analyzed using the Sta-tistical Package for the Social Sciences (SPSS) version 29.01.0(171). The chi-square test was used to determine the relationship between nutritional knowledge and the

inde-pendent variables (age, area of residence, education, and monthly income). The statisti-cal significance level was P<0.05.

Results

A sample of 372 mothers from the Cabinda Integrated Project was selected to participate in the study. Sociodemographic data analysis revealed that the majority of mothers, 152 (40.86%), were between the ages of 25 and 34, followed by 103 (27.69%) between 18 and 24 years old, 79 (21.24%) between 35 and 45 years old, 28 (7.53%) be-tween 16 and 17 years old, 8 (2.15%) over 45 years old, and 2 (0.54%) under 15 years old, as shown in Figure 1.

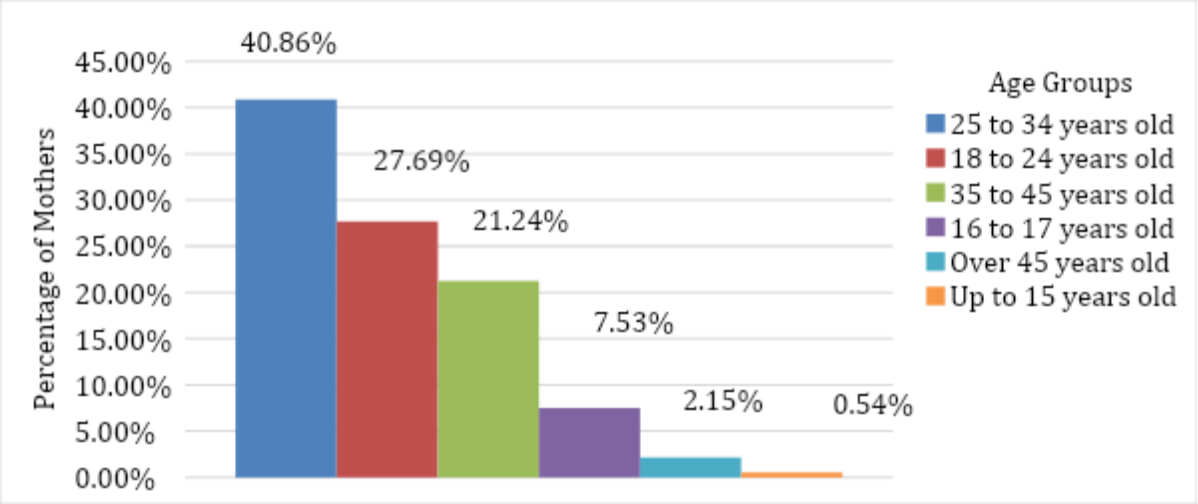

Figure 1. Distribution of Cabinda Integrated Project Mothers by Age Group, 2023

Area of Residence

Regarding the area of residence, Figure 2 shows that 215 (57.80%) of the mothers re-sided in urban areas, while 157 (42.20%) resided in rural areas.

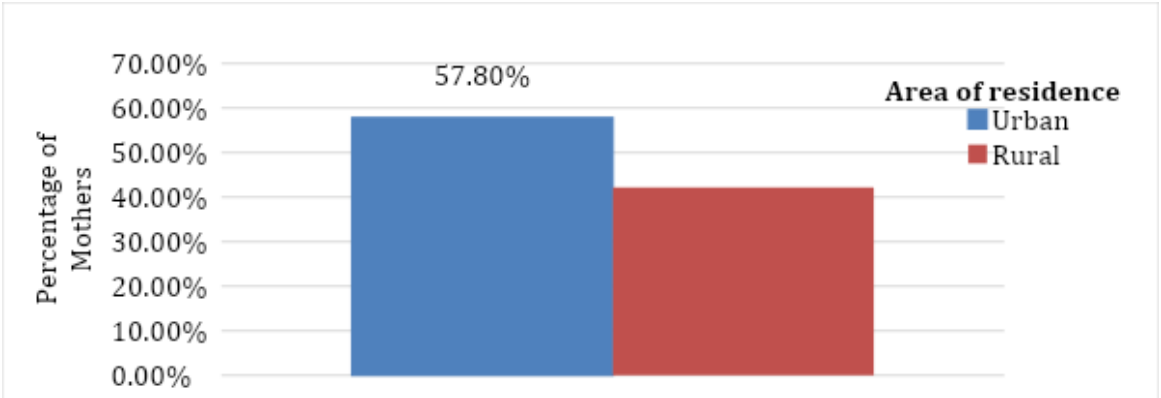

Figure 2. Distribution of Cabinda Integrated Project Mothers by Area of Residence, 2023

Analysis of Marital Status

Figure 3 illustrates the marital status distribution of the participating mothers. The ma-jority of the participants identified as single, accounting for 207 (55.65%) of the sample. This was followed by those in stable unions (148 or 39.78%), married individuals (9 or 2.42%), and divorced mothers (2.15%).

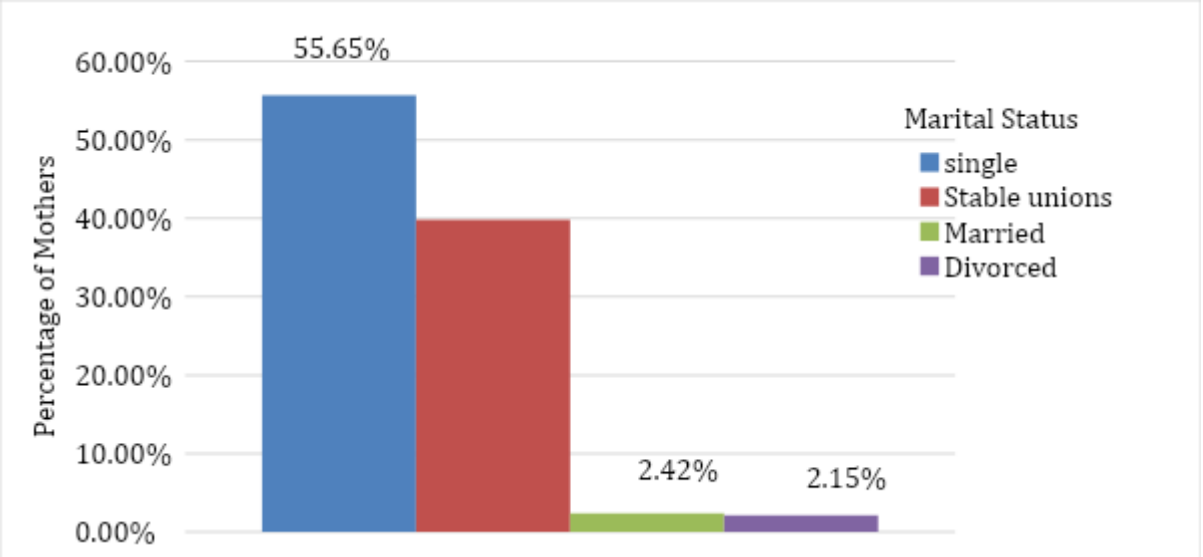

Figure 3. Distribution of Marital Status among Mothers in the Cabinda Integrated Project, 2023.

Religious Affiliation

Figure 4 presents the religious affiliations of the participating mothers. The majority of the participants identified as Catholic, accounting for 194 (52.15%) of the sample. This was followed by those belonging to evangelical churches (110 or 29.57%), Pentecostal churches (25 or 6.72%), the Kimbanguist Church (17 or 4.57%), other denominations (16 or 4.30%), the New Apostolic Church (6 or 1.61%), and the Tocoísta Church (4 or 1.08%).

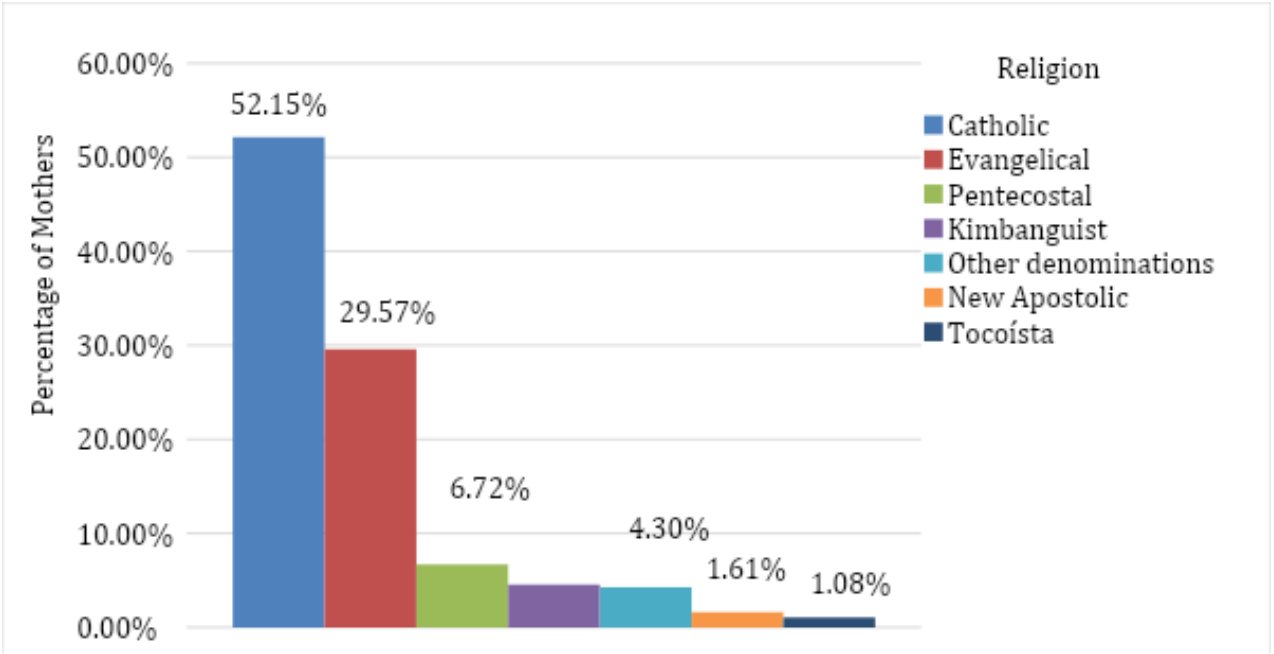

Figure 4. Distribution of Religions among Mothers in the Cabinda Integrated Project, 2023.

Occupational Analysis

Figure 5 presents the occupational distribution of the participating mothers. The data reveals that a significant portion of the mothers were unemployed, accounting for 97 (26.08%) of the sample. This was followed by those who identified as students (92 or 24.73%), those engaged in informal work (72 or 19.35%), employed individuals (67 or 18.01%), public servants (26 or 6.99%), interns (2 or 0.54%), an entrepreneur (1 or 0.27%), and a self-employed individual (1 or 0.27%).

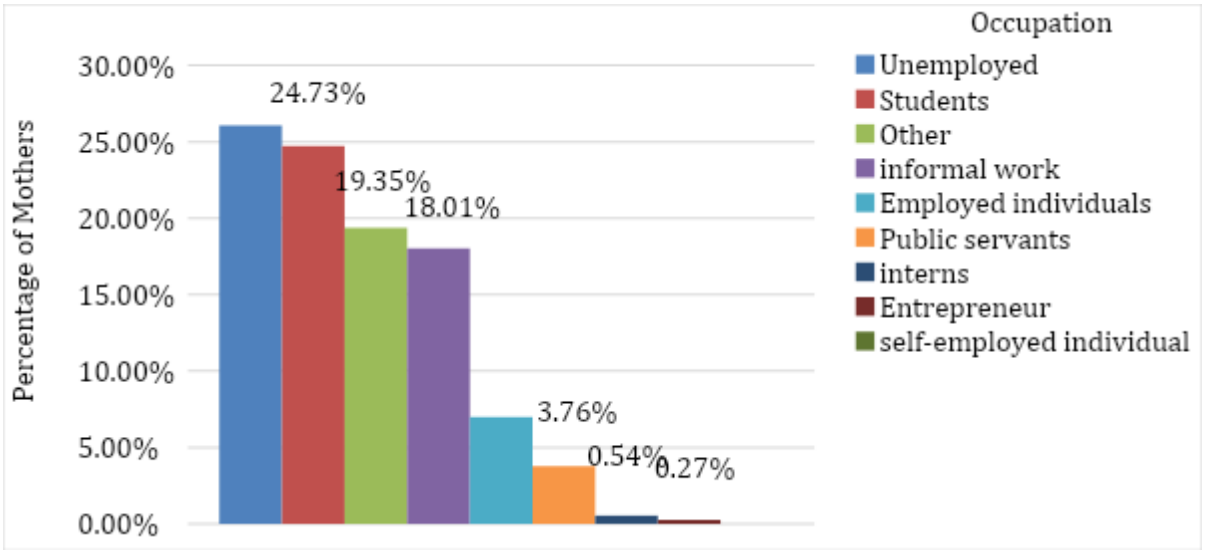

Figure 5. Occupational Distribution of Mothers in the Cabinda Integrated Project, 2023

Educational Analysis

Figure 6 presents the educational attainment distribution of the participating mothers. The data reveals that a significant portion of the mothers had completed incom-plete secondary education, accounting for 79 (21.24%) of the sample.

This was followed by those with completed secondary education (68 or 18.28%), completed lower secondary education (grades 7-9) (53 or 14.25%), no formal education (51 or 13.71%), completed primary education (35 or 9.41%), incomplete lower second-ary education (grades 7-9) (33 or 8.87%), incomplete primary education (31 or 8.33%), incomplete higher education (10 or 2.69%), completed higher education (9 or 2.42%), and those who had only completed literacy education (3 or 0.81%).

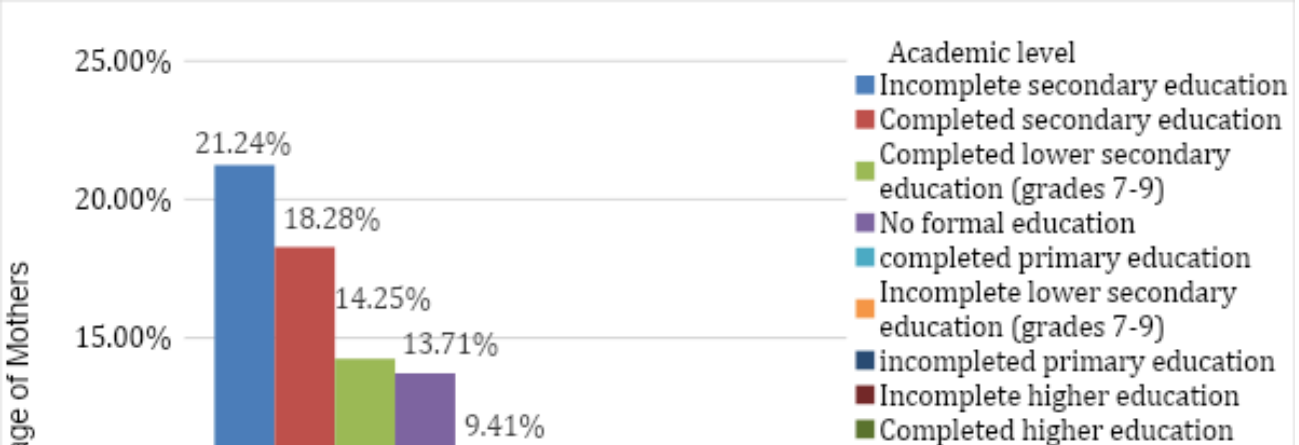

Figure 6. Distribution of Educational Attainment among Mothers in the Cabinda Integrated Pro-ject, 2023

Income Analysis

Figure 7 presents the distribution of monthly income among the participating mothers. The general trend of the data is that the majority of mothers (30.91%) earn between 10,000 and 70,000 Kwanzas per month. This is followed by mothers earning between 100,001 and 150,000 Kwanzas (28.76%). A significant portion of mothers (12.37%) reported no monthly income.

Additionally, 24 (6.45%) mothers earned between 200,001.00 and 300,000.00 Kwanza, while a smaller group of 4 (1.08%) earned more than or equal to 500,001.00 Kwanza. Another 4 (1.08%) mothers reported earning between 300,001.00 and 500,000.00 Kwanza.

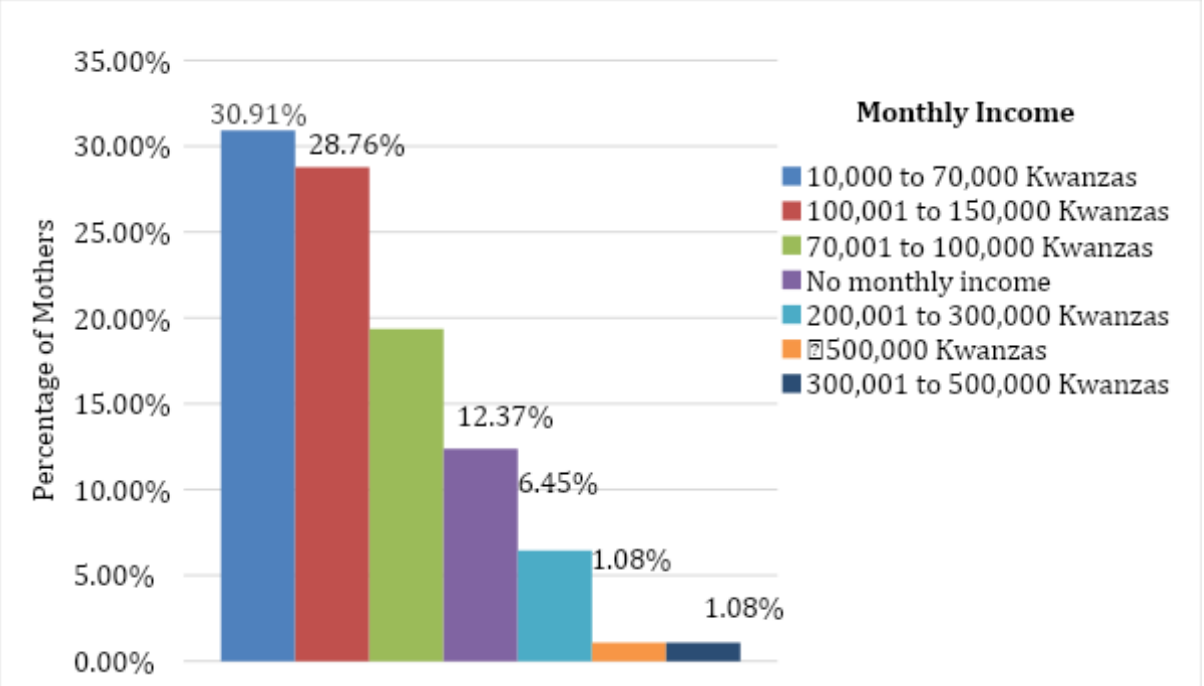

Figure 7. Distribution of Monthly Income among Mothers in the Cabinda Integrated Project, 2023

Knowledge of Mothers Regarding Infant Nutrition and Feeding Practices

The findings presented in Table 1 indicate the accuracy rates achieved by the mothers who participated in this assessment. The table reveals that the mothers' knowledge is varied. In this case, the mothers demonstrated high levels of accuracy in three questions:

Question 27: When preparing a child's plate, it is essential to present the food items separately so that the child can recognize different flavors and textures. 98.12% of the sample achieved the highest level of nutritional knowledge in this question.

Question 24: Cow's milk, whether powdered or liquid, should not be offered to children under one year of age as it can cause anemia. 93.55% of respondents demonstrated ac-curate knowledge in this question.

Question 8: Efforts should be made to feed children with locally available, healthy, and easily accessible and prepared foods. The accuracy score for this question was 92.47%.

Another significant finding of this study is the above-average level of unaware-ness displayed by a large proportion of these mothers in many of the questions. For in-stance, 67.20% of the mothers do not believe that exclusive breastfeeding (EBF) should be offered to a child from birth until six months of age.

Regarding the establishment of mealtimes for infants: 91.13% of the mothers emphasized the importance of setting specific times for offering meals to children.

Regarding food preparation methods: 91.13% of the mothers evaluated demon-strated that the finer the soup or porridge, the better the absorption of vitamins for the child.

Regarding food portion sizes: 91.13% of the mothers stated that food should be offered in pieces to babies from 8 months of age onwards, without regard to the size of the pieces.

Regarding feeding methods: 88.98% of the mothers believe that if a child refuses to eat, they should be motivated in some way (reward or punishment) to finish the meal.

Regarding food preparation: 72.04% of the participants were unaware that be-fore starting to prepare food, they should soak it in clean water mixed with bleach or hypochlorite and then rinse it with water only.

Regarding hygiene practices: 93.82% of the mothers agreed that it is not neces-sary to wash the child's hands before meals, as they will not be the ones handling the food.

Regarding food variety: 81.72% of the mothers believe that the food prepared for a child's meal should be used throughout the day to prepare their other meals.

Table 1. Knowledge of Mothers Regarding Infant Nutrition and Feeding Practices.

Nº	Questions	Hits	%
1	Exclusive Breastfeeding (EB) is recommended for infants from birth to 6 months of age. After 6 months, breastfeeding should continue along with complementary foods until the child is two years old or older.	122	32,80%
2	Continue breastfeeding your child alongside complementary foods until they are two years old or older	224	60,22%
3	At 6 months of age, introduce other liquids (such as water and tea) and solid foods in addition to breast milk	321	86,29%
4	Set regular mealtimes for your child when introducing complementary foods	33	8,87%
5	Give cow's milk (powdered or liquid) only after one (1) year of the child's life	124	33,33%
6	Meat contains less iron than vegetables	127	34,14%
7	At 6 months, avoid giving your child iron-rich foods like meat, vegetables, and greens	114	30,65%

8	Feed your child healthy foods that are readily available and easy to prepare in your area	344	92,47%
9	Introduce fruits and vegetables into your child's diet during the first year of life	241	64,78%
10	Provide foods with low amounts of sugar and salt or without these ingredients altogether	232	62,37%
11	Even if your child shows signs of hunger, avoid offering snacks (such as plain fruits or crackers) between meals	209	56,18%
12	Exclude sugar, coffee, canned foods, fried foods, sodas, candies, snacks, sweets, excess salt, and ready-to-eat foods (instant noodles, bouillon cubes) from your child's diet	236	63,44%
13	Do not give breast milk if the child is sick, because it no longer has the vitamins that the child needs	293	78,76%
14	In order for the child to accept a food offered for the first time, a single presentation to the food is required	216	58,06%
15	During complementary feeding, ensure your child's diet includes at least four food groups: grains, tubers, vegetables, legumes/meat	270	72,58%
16	Always mix food before feeding the child	99	26,61%
17	The purees prepared for the baby should be thick enough to stay on the spoon even after turning it over	212	56,99%
18	Purchased ready-to-eat foods (soups, juices) are not recommended for babies	228	61,29%
19	The thinner the soup or porridge, the better the use of vitamins for the child	33	8,87%
20	From the age of six months, the food offered to babies should only be kneaded, never blended or strained	284	76,34%
21	We should offer food in pieces to the baby from 8 months of age without caring about the size of the pieces	33	8,87%
22	At the age of 1, the child should eat the same meal as the family, as long as the food is low in fat and salt, respecting the needs of the child	284	76,34%
23	Cow's milk (powder or liquid) should not be offered to children under 1 year of age, as it can cause anemia	112	30,11%
24	From the age of six months, the child should receive supplementation of vitamins A, C, D and iron	348	93,55%
25	When feeding the baby, show patience and respect when the child is satisfied	173	46,51%
26	If the child refuses to eat, motivate him in some way (reward or punishment) to finish the meal	41	11,02%
27	When assembling the child's plate, it is essential that the food is presented separately, so that the child can recognize the different flavors and consistencies	365	98,12%
28	It is not necessary to encourage the child to eat alone	271	72,85%
29	It is important that food in the first months of food introduction is prepared exclusively for the child	202	54,30%
30	Before starting to prepare food, soak it in clean water mixed with bleach or hypochlorite and rinse it afterwards with water only	104	27,96%

31	You don't need to wash your child's hands before the meal, as they won't be the same one who picks up the food	23	6,18%
32	The food prepared for the child's meal should be used throughout the day for the preparation of his other meals	68	18,28%
33	From the beginning of the introduction of new foods encourage and offer the food to the child using a cup, plate and cutlery	51	13,71%
34	The bottle should be used to offer liquids to the child	262	70,43%
35	Objects to prepare the child's food must be well washed, dried and stored in a cool place, covered or covered in a larger container, free from contact with insects and other objects of use by all, and their use is exclusive to the child	309	83,06%

Nutritional Knowledge of Mothers in the Cabinda Integrated Project

An assessment of the overall nutritional knowledge of mothers participating in the Cabinda Integrated Project revealed that slightly over half (51.34%) demonstrated good knowledge, while 46.24% exhibited moderate knowledge. A small percentage (1.34%) had insufficient knowledge and only 1.08% showed very good knowledge, as shown in Table 2.

Table 2. Level of General Nutritional Knowledge on Infant Feeding among Mothers in the Ca-binda Integrated Project, 2023.

Level of Knowledge									
Total		Insufficient		Moderate		Good		Very Good	
N	%	*N*	%	N	%	N	%	N	%
372	100%	5	1,34%	172	46,24%	191	51,34%	4	1,08%
372	100%	5	1,34%	172	46,24%	191	51,34%	4	1,08%

Relationship between Participants' Nutritional Knowledge and Age

While the data presented in Table 3 suggests no statistically significant correlation between participants' nutritional knowledge and their age (p = 0.497), a closer ex-amination reveals a more nuanced picture.

Interestingly, within the youngest age group (mothers 15 or younger), a balanced distribution of knowledge was observed. Half of the mothers demonstrated a "reasona-ble" understanding of infant feeding practices, while the other half exhibited "good" knowledge. It's noteworthy that no mothers in this age group scored within the "insuffi-cient" or "very good" knowledge categories. This finding may warrant further investiga-tion to understand the specific sources of knowledge acquisition for these young moth-ers.

As we move through the subsequent age groups, a gradual trend emerges. Among mothers aged 16-17, "reasonable" knowledge remains prevalent (64.29%), with a nota-ble portion (35.71%) exhibiting "good" knowledge. Similar to the youngest age group, no mothers fell within the "insufficient" or "very good" categories. For mothers aged 18-24, "reasonable" knowledge continues to be the most common (55.77%), but the pro-portion of mothers with "good" knowledge increases (40.38%). A small percentage (2.88%) within this age group scored as having "insufficient" knowledge,

Age(Years)	Knowledge Level										P-value
	Total		Insufficient		Reasonable		Good		Very Good		
	N	%	N	%	N	%	N	%	N	%	
Up to 15	2	0,54%	0	0,00%	1	50,00%	1	50,00%	0	0,00%	0,497
16 to 17	28	7,53%	0	0,00%	17	60,71%	11	39,29%	0	0,00%	
18 to 24	103	27,69%	3	2,91%	56	54,37%	43	41,75%	1	0,97%	
25 to 34	152	40,86%	2	1,32%	63	41,45%	84	55,26%	3	1,97%	
35 to 45	79	21,24%	0	0,00%	32	40,51%	47	59,49%	0	0,00%	
Over 45	8	2,15%	0	0,00%	3	37,50%	5	62,50%	0	0,00%	
Total	372	100%	5		172		191		4		

suggesting potential knowledge gaps that could be addressed through targeted interventions.

The data indicates a shift in knowledge distribution within the older age groups (25 and above). The majority of mothers aged 25-34 possess "good" knowledge (55.26%), with a significant portion demonstrating "reasonable" knowledge (41.45%).

It's also noteworthy that a small percentage (1.97%) within this age group scored within the "very good" knowledge category, potentially reflecting personal experiences or exposure to additional educational resources. The trend of mother's exhibiting "good" knowledge continues in the 35-45 age group, with an even higher prevalence (59.49%).

"Reasonable" knowledge remained present (40.51%), with no mothers falling within the "insufficient" or "very good" categories in this age group. Finally, mothers over 45 years old displayed the strongest knowledge base, with the majority (62.50%) demonstrating "good" knowledge and the remaining portion (37.50%) exhibiting "rea-sonable" knowledge. Similar to the older age groups, there were no mothers in this cat-egory with "insufficient" or "very good" knowledge levels.

While no statistically significant correlation was found between age and nutritional knowledge, this analysis highlights a potential trajectory of knowledge acquisi-tion.

Table 3. Relationship between nutritional knowledge on infant feeding and participants' age.

Nutritional Knowledge Distribution by Educational Attainment

While the data presented in Table 4 suggests no statistically significant difference in overall nutritional knowledge across various educational attainment levels (p=0.051), a closer examination reveals a more nuanced picture. Interestingly, mothers who had not completed higher education exhibited a promising proficiency in nutri-tional knowledge, with a prevalence of 80% demonstrating a good understanding of this critical subject area. Conversely, mothers with completed lower secondary education (7th to 9th grade) primarily displayed a reasonable level of knowledge, reflected in a score of 58.49%.

Table 4. Relationship between mothers' knowledge about infant feeding and their educational attainment

Educational Attainment	Total	Insufficient Knowledge	Reasonable Knowledge	Good Knowledge	Very Good Knowledge	P-value
Incomplete Primary Education	31	0 (0%)	9 (29.03%)	22 (70.97%)	0 (0%)	0,051

Complete Primary Education	35	0 (0%)	13 (37%)	22 (62.86%)	0 (0%)
Literacy Education	3	0 (0%)	3 (100%)	0 (0%)	0 (0%)
Lower Secondary Education (7th to 9th Grade) - Complete	53	1 (2%)	31 (58.49%)	20 (37.74%)	1 (1.89%)
Lower Secondary Education (7th to 9th Grade) - Incomplete	33	2 (6%)	12 (36%)	19 (57.58%)	0 (0%)
Incomplete Secondary Education	79	0 (0%)	42 (53.16%)	37 (46.84%)	0 (0%)
Complete Secondary Education	68	2 (3%)	27 (39.71%)	36 (52.94%)	3 (4.41%)
Incomplete Higher Education	10	0 (0%)	2 (20%)	8 (80%)	0 (0%)
Complete Higher Education	9	0 (0%)	5 (55.56%)	4 (44.44%)	0 (0%)
Never Studied	51	0 (0%)	28 (54.90%)	23 (45.10%)	0 (0%)
Total	372	5	172	191	4

Nutritional Knowledge Distribution by Area of Residence

Table 5 sheds light on a compelling association between a mother's place of residence and her level of nutritional knowledge. This relationship is statistically significant, as evidenced by a p-value of 0.0001. A closer look at the data reveals a geographically differentiated knowledge landscape. Mothers residing in rural areas exhibited a distinct prevalence of good nutritional knowledge, with a remarkable 75.80% demonstrating a strong understanding of this critical topic. Conversely, mothers dwelling in urban areas primarily displayed a reasonable level of knowledge, reflected in a score of 63.72%.

Table 5. Relationship between mothers' knowledge about infant feeding and area of residence

Monthly Income (in Kwanzas)	Total	Insufficient Knowledge	Reasonable Knowledge	Good Knowledge	Very Good Knowledge	P-value
10,000 to 70,000	115	4 (3.48%)	43 (37.39%)	67 (58.26%)	1 (0.87%)	
100,001 to 150,000	107	0 (0%)	61 (57.01%)	46 (42.99%)	0 (0.00%)	
70,001 to 100,000	72	1 (1.39%)	28 (38.89%)	41 (56.94%)	2 (2.78%)	
200,001 to 300,000	24	0 (0%)	18 (75.00%)	6 (25.00%)	0 (0.00%)	0,0001
300,001 to 500,000	4	0 (0%)	3 (75.00%)	1 (25.00%)	0 (0.00%)	
≥500,000	4	0 (0%)	1 (25.00%)	2 (50.00%)	1 (25.00%)	

No monthly income	46	0 (0%)	18 (39.13%)	28 (60.87%)	0 (0.00%)
Total	372	5	172	191	4

Discussion

The assessment of nutritional knowledge among mothers participating in the Integrated Cabinda Project revealed a complex scenario. While just over half (51.34%) of mothers demonstrated good knowledge of infant feeding, a significant proportion (46.24%) exhibited only moderate knowledge. This result is similar to studies conducted in São Luís, Brazil (53.5%) and Malaysia (68.3%) (11, 12), indicating the need to deepen nutritional education interventions in the region. Compared to other studies in similar contexts, the data reveal that, despite efforts, there is still room for improvement in mothers' nutritional knowledge.

The evidence from this study shows that the mothers evaluated have a very low level of knowledge about the issue of breastfeeding. Thus, these results indicate that 67.20% of the mothers evaluated are unaware that exclusive breastfeeding (EBF) should be offered to the child from birth until 6 months of life, coinciding with this find-ing. Similar results were found in a Brazilian study, where 78.3% of the participants studied did not know the correct duration of the exclusive breastfeeding period (13).

However, studies conducted in Italy and Nigeria showed opposite results, where 71% and 80.2% of the mothers surveyed were more aware of the recommended dura-tion of the exclusive breastfeeding period (14,15)

In relation to the place of residence, the results of this study show that mothers living in rural areas (75.80%) are more likely to have good knowledge than mothers living in urban areas (33.49%). A study conducted in the Free State Province, South Afri-ca, showed similar results, indicating that 34.2% of rural residents had good levels of nutritional knowledge, compared to 22.6% of urban residents (16).

Still, the findings of this study agree with the results of a study conducted in one of the Tuhuledere Woreda areas in Ethiopia, showing that rural mothers (37%) were more likely to have good nutritional knowledge compared to semi-urban mothers (34%) (17). Non-governmental organizations in partnership with local governments have promoted more nutritional education programs in rural communities than in ur-ban areas, it seems that this disparity may mean that mothers in rural areas have more knowledge than in urban areas. An Indian study revealed that the greater presence of health activists in rural areas was related to the good levels of knowledge among moth-ers in this region compared to those in urban areas (18).

The evidence from this study showed that maternal nutritional knowledge was positively associated with monthly family income. It can be found that mothers without income probably have good nutritional knowledge. The result was similar to a study conducted with pregnant women in Ethiopia, revealing that mothers with high income had a low level of knowledge about infant feeding compared to mothers with low in-come. However, the authors report that there is a statistically significant difference be-tween the nutritional knowledge and monthly income of the mothers (Tesfa et al., 2022). This distinction, can be attributed to the fact that several nutritional and food education programs in Cabinda focus on more vulnerable social groups, which encour-ages mothers to acquire more knowledge about food.

Another study in Somalia showed that knowledge of infant feeding among moth-ers with children under 2 years of age was positively associated with maternal income (20), thus coinciding with the results of this study.

Although there was no statistically significant difference between maternal ages in infant feeding knowledge, this study found that mothers over 25 years of age achieved better levels of nutritional knowledge. Similar evidence was presented in a study con-ducted in the rural areas of Brobo, Côte d'Ivoire, indicating that mothers aged 25 or over had more nutritional knowledge than younger women, although the difference was not statistically significant (21).

The findings of this study are in line with the results of a study conducted among Nigerian mothers, where it was possible to observe that there is no statistically significant correlation between maternal age and the level of knowledge about complemen-tary foods (15).

In addition, a study conducted in Limpopo, South Africa, with mothers of children under 2 years of age reinforced that evidence confirming a statistically significant rela-tionship between these two variables was not found (21).

Even though there was no statistically significant difference in the education of the participants in this study, the statistical analysis showed that mothers with incom-plete higher education had good knowledge. The results of a study evaluating maternal nutritional knowledge about infant diet and nutritional practices in the Karachi district, Pakistan, clearly show that there is no statistically significant relationship between ma-ternal knowledge and education (22).

A study of mothers attending a hospital in Ekiti State, Nigeria, found no significant association between mothers' knowledge of complementary feeding introduction and their educational levels (23). In addition, it was found in the evidence from a study conducted in the Rajshahi District, Bangladesh, that the mothers' educational level did not have a positive effect on their nutritional knowledge in relation to child feeding (24).

In contrast to these results, data from a study conducted in the city of Unaizah, Saudi Arabia, showed that both maternal education and age were positively correlated with maternal and child knowledge (25).

Another study conducted in Assiut Province, Egypt, showed that age and educa-tion likely had a positive effect on maternal knowledge levels about infant and young child nutrition (26) .

Conclusions

This study assessed the level of nutritional knowledge among mothers participat-ing in the Cabinda Integrated Project in Angola. The findings reveal that over half (51.34%) of the mothers demonstrated adequate nutritional knowledge regarding in-fant feeding practices. However, a significant portion (46.24%) exhibited only moderate knowledge, highlighting the need for targeted interventions.

Interestingly, the study identified a lack of statistically significant correlation be-tween mothers' age and their nutritional knowledge. However, a closer analysis sug-gests a potential trajectory of knowledge acquisition, with mothers in older age groups demonstrating a stronger knowledge base.

Furthermore, while no statistically significant difference was found in overall knowledge based on educational attainment, mothers who had not completed higher education displayed a surprisingly high prevalence of good knowledge. This may

sug-gest the effectiveness of alternative knowledge dissemination channels outside of for-mal education systems.

In contrast, mothers with completed lower secondary education primarily exhib-ited a reasonable level of knowledge. This finding underscores the need to tailor educa-tional interventions to address knowledge gaps within specific educational attainment groups.

The study also revealed a surprising disparity in knowledge based on area of res-idence. Mothers residing in rural areas demonstrated a significantly higher level of knowledge (75.80%) compared to their urban counterparts (33.49%). This finding war-rants further investigation to understand the potential factors contributing to this dif-ference.

These results suggest that interventions aimed at improving mothers' nutritional knowledge should consider a multifaceted approach. Age, education level, and area of residence should all be factored into the design and implementation of these programs.

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Conflict of Interest

I declare that the work submitted for publication in the MLS Health & Nutrition Research Journal is original and has not been or is not currently under review in any journal or conference. Likewise, I am responsible for its content and agree that my name be included as an author. Finally, I declare that I have no conflict of interest in those ac-tivities that could introduce bias into the results of the work.

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Effect and comparison of the ketogenic, mediterranean and low glycemic index in the treatment of ovarian syndrome polycystic (PCOS)

Efecto y comparación de la dieta cetogénica, mediterranea y de bajo índice glucemico en el tratamiento del síndrome de ovario poliquístico (SOP)

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ABSTRACT

To analyze and compare the effect of ketogenic, mediterranean, and low glycemic index diets in the treatment of women with polycystic ovary syndrome (PCOS), evaluating the improvement of symptoms and evolution of the pathology. A bibliographic review based on the study of high-quality scientific articles found through databases was conducted for the complete preparation of this review. Studies indicate that any of the three dietary patterns can be an effective treatment for PCOS, depending on the aspects being treated. All low-calorie diets are effective for women with PCOS who are overweight and obese, improving associated symptoms. The ketogenic diet (KD) is beneficial in the short term for weight loss and glycemic control, although it is highly restrictive and difficult to maintain in the long term. The Mediterranean diet (MD), with less efficient in the short term, improves general health, has a high antioxidant capacity, and is evidenced to be more sustainable in the long term. The low glycemic index (GI) diet does not show conclusive results for PCOS but may improve the sex hormone profile and lipid profile parameters. A combined strategy of several dietary patterns can improve both short- and long-term results.: To provide a more specific treatment for PCOS, more studies with greater evidence and higher quality are necessary. However, it can be concluded that the dietary models studied, according to the symptoms and needs of the patients, possess the necessary characteristics to achieve improvements, constituting a vital part of the treatment of women with PCOS.

RESUMEN

Palabras clave:
Síndrome de ovario poliquístico (SOP), Dieta cetogénica (DC), Dieta mediterránea (DM), Dieta de bajo índice glucémico (IG), Tratamiento del SOP

Analizar y comparar el efecto de las dietas cetogénica, mediterránea, y de bajo índice glucémico como tratamiento en mujeres con síndrome de ovario poliquístico (SOP), evaluando la mejora de los síntomas y evolución de la patología. Revisión bibliográfica basada en el estudio de artículos científicos de la mayor calidad encontrada a través de bases de datos para la elaboración total de la revisión. Los estudios indican que los tres patrones dietéticos pueden ser un tratamiento efectivo para el SOP, dependiendo de los aspectos a tratar. Las dietas hipocalóricas resultan efectivas para mujeres con SOP que padecen sobrepeso y obesidad, mejorando los síntomas asociados. La dieta cetogénica (DC) es beneficiosa a corto plazo, aunque es restrictiva y difícil de mantener a largo plazo para lograr resultados sostenibles. La dieta mediterránea (DM), menos eficiente a corto plazo, mejora la salud general, tiene una alta capacidad antioxidante y evidencia de ser más sostenible a largo plazo. La dieta de bajo índice glucémico (IG) no muestra resultados concluyentes para el SOP, pero mejora el perfil hormonal y parámetros del perfil lipídico. Una estrategia combinada de varios patrones dietéticos puede mejorar los resultados tanto a corto como a largo plazo.

Para ofrecer un tratamiento más específico frente al SOP, son necesarios más estudios con mayor evidencia y calidad. Sin embargo, se puede concluir que los modelos dietéticos estudiados presentan, según la sintomatología y las necesidades, las características necesarias para lograr mejoras. Constituyendo una parte vital del tratamiento en mujeres con SOP

Introduction

Polycystic ovarian syndrome (PCOS) is a chronic disorder present in

the main cause of this disease, which affects mainly the metabolic and endocrine system, has different short and long term impacts during the entire fertile life (1)the prevalence is 6 to 20% and is characterized by anovulation, hyperandrogenism and polycystic ovarian morphology (2). Usually diagnosed in adolescence during menarche, the first menstruation, with the use of gynecologic ultrasound as the primary diagnostic method (3).

It is considered a disease with heterogeneous symptomatology associated with metabolic and endocrine factors, which are related to other pathologies such as cardiovascular disease, type 2 diabetes mellitus (DM2) and insulin resistance (IR), as well as different long-term consequences (4).

Among the most prominent symptoms of PCOS, which significantly impact quality of life, are reproductive, metabolic and cardiovascular problems. Reproductive problems include cycle irregularity, infertility and complications during pregnancy. As for metabolic problems, DM2 is especially prevalent among women who are overweight or obese, affecting between 40% and 80% of women with PCOS (4) (4). In addition, a high incidence of cardiovascular disease and IR is observed. More recently, psychological problems, such as anxiety and depression, have been recognized as important components in PCOS (1,3) (1,3).

The main treatment for PCOS consists in the implementation of a healthier lifestyle, focused on improving the diet, with the aim of improving the quality of life of the patients (2). Diet is one of the most effective and beneficial treatments for both improving the symptomatology of PCOS and addressing associated conditions such as hyperinsulinemia and obesity (4). It is crucial that these dietary interventions be accompanied by appropriate medical and nutritional follow-up to tailor recommendations to the individual needs of each patient (3-5).

At the clinical level there is a need to determine a more concise treatment as there is a great deal of misinformation and confusion in the population about PCOS in general. It is a topic of personal relevance to me as I was diagnosed with PCOS a few years ago. In addition to the clinical symptoms that this syndrome presents and the complications that it can cause in the long term, experiencing it personally gives me a direct insight into the subject at hand.

Method

A bibliographic search was carried out in different databases for specific articles related to the topics to be addressed.
The databases used to begin the search were:

-PubMed: Establishing the present filters specific to the database: maximum publication date of 5 years. Using as keywords in your search *Polycystic ovary syndrome treatment, Chronic PCOS*, *Polycystic ovary syndrome epidemiology*, *Polycystic Ovary Syndrome AND Diet Ketogenic, Ketogenic diet treatment, Diet Mediterranean[Majr] AND Polycystic Ovary Syndrome, Polycystic ovary syndrome AND low glycemic index.*

- Google Scholar: This search engine was very useful for accessing the full text of various articles or for searching official web pages, as well as for accessing guides related to the topic to be covered. Using as keywords for your main search *Polycystic Ovary Syndrome*.

Inclusion criteria were experimental studies, clinical trials, case-control studies, cohort studies or observational studies or reviews in the case of providing demographic or theoretical data. With a population of women of childbearing age between 15 and 45 years, with a diagnosis of PCOS. Women with associated diseases or different BMIs were not excluded as part of the study was the relevance of environmental conditions in the predisposition and development of the syndrome. The articles used for the main discussion were published between 2019 and 2024, with the exception of the use of previously published articles that were highly relevant to provide a scientific basis.

Exclusion criteria were based on studies of little relevance to the study including systematic or literature reviews, in-vitro studies and expert experience. In addition, those studies developed in animals, specific to the male sex or with active treatments to treat other adjacent metabolic diseases.

Results

The nutritional approach to polycystic ovary syndrome (PCOS) is presented as a vital tool for the improvement of the pathology along with its associated factors and an improvement in the quality of life (6). We will begin by analyzing the studies related to the ketogenic diet and PCOS. These are supplemented by the information in Table 1. All the studies found were carried out in overweight and obese women, attributing most of the results to the benefits obtained, as they were hypocaloric diets, with weight reduction. In contrast to the study by Paoli et al. (4) results were not very conclusive as the small sample size and the short time to which the subjects were exposed were not considered sufficiently significant for the treatment of PCOS. While the study by Cincione et al. (7) used a greater amount of protein to preserve muscle mass. Improving symptomatology together with biochemical and anthropometric parameters, it is considered effective in a short period of time but highly hypocaloric and not recommended for long-term treatment as it is not clear whether it would continue to be beneficial. The final results were remarkable in the regulation of the menstrual cycle and an increase in fertility with improvements in all the women who completed the study.

The study by Magagnini et al. (8) obtained more significant results in the improvement of ovarian function and found a greater relationship with fertility, and also obtained improvements in both anthropometric and hormonal parameters, highlighting the improvement of progesterone. This study stands out for its greater adherence, since all subjects completed the study, being one of the longest follow-up periods compared to the other studies. While following the restrictive and hypocaloric pattern, nutrients were given prominence in the dietary guidelines. One of the values highlighted in the three studies (4,7,8) was the reduction in testosterone levels, although the lack of clinical improvement was highlighted as the time of action was not long enough to make such observations. Finally, the clinical study conducted by Yang et al. (9) stated that it was possible to conserve muscle mass by performing a hypocaloric CD, reducing visceral fat and lowering blood sugar levels. This was the study in which the least improvement in

analytical and anthropometric parameters was observed, in contrast to the previous studies, which could be due to a lower caloric restriction.

Table 1. Studies on ketogenic diet treatment in women with PCOS.

Author, year and reference	Type of study	Population	Features	Exclusion and inclusion criteria	Results
Paoli et al., 2020(4)	Uncontrolled trial	14 overweight and obese women with polycystic ovary syndrome	Duration of 12 weeks. Study of the ketogenic Mediterranean diet with phyoextracts. Evaluation of body weight, BMI, fat and lean body mass, visceral adipose tissue, lipid profile, insulin, glucose, HOMA-IR, and hormone profile. Place of origin: Italy	Inclusion criteria: diagnosis of PCOS through the Rotterdam criteria, age between 18 to 45 years, a BMI $\geq$ 25 kg/m2, desire to lose weight and not using contraceptives. Exclusion criteria: pregnancy or lactation, hormone therapy, insulin sensitivity, liver, kidney or heart disease.	No significant results were obtained in oligoamenorrhea or infertility. Androgen hormone levels decreased significantly. An average weight reduction of 9.43 kg was obtained along with a reduction in BMI, fat mass and visceral adipose tissue.
Cincione et al., 2021 (7)	Uncontrolled trial	17 overweight and obese women with polycystic ovary syndrome	Duration of 45 days. Study of the mixed ketogenic diet to establish ketosis while preserving lean mass. Evaluation of clinical and gynecological history, nutritional status, body composition and biochemical measurements. Place of origin: Italy	Inclusion criteria: BMI > 25, fertile age between 18 and 45 years, diagnosis of PCOS according to the Rotterdam Criteria, no contraceptive use and desire to lose weight. Exclusion criteria: pregnancy or breastfeeding, renal, hepatic or cardiac diseases, episodes of gout or hyperuricemia, estrogenic-progestagenic or insulinosensitizing pharmacological treatment in a period of less than one year.	Reduction of blood glucose, androgen and estrogen levels and improvement of insulin sensitivity. An average weight loss of 9.4% was obtained, together with a 3.6% reduction in BMI. Five of the seventeen patients with amenorrhea recovered their regular menstrual cycle, improved their cycles and five achieved a natural pregnancy after low fertility.
Magagnini et al., 2022 (8)	Uncontrolled trial	25 overweight and obese non-diabetic women with polycystic ovary syndrome and regular menstruation	Duration of 12 weeks. Very low calorie ketogenic diet (VLCKD) study Evaluation of anthropometric and blood parameters. Place of origin: Italy	Inclusion criteria: over 18 years of age, diagnosis of PCOS according to the Rotterdam Criteria, family history of DM2, regular menstrual cycle intervals and male couples with normozoospermia. Exclusion criteria: DM1, DM2, chronic renal failure, active or severe infections, cardiac arrhythmias, frailty,	Seventy-five percent of the patients reduced their weight. 96% improved serum AMH levels along with progesterone. 100% of the women improved in ovulatory dysfunction. 19 of the 25 patients went from obese to overweight BMI and the HOMA index normalized in 24 of the 25 patients.

				previous 48-h surgery, invasive procedures, psychiatric disorders, irregular menstrual cycles.	
Yang et al. 2022**,** (9)	Clinical trial	55 overweight and obese women with polycystic ovary syndrome	Duration of 12 weeks. Study of the effects of ketogenic diet on uric acid concentrations. Evaluation of weight, BMI, body fat percentage, fasting blood glucose, triglycerides, total cholesterol and uric acid. Place of origin: China	Inclusion criteria: BMI of ≥24 kg/m ^{2,} women of childbearing age between 20-40 years.	Maintenance of muscle mass along with reduction of total weight, BMI, total fat and hyperuricemia. The analytical and anthropometric values showed similar results at the beginning and end of the study.

To continue, studies related to the Mediterranean diet and PCOS will be discussed. These are detailed in **Table 2**.

Some of the studies (10-12) used the PREDIMED score as a method of evaluation, which is mostly used to determine adherence to DM, but it was observed that it does not provide absolute results and other parameters should be taken into account. The study by Barrea et al. (10) did not determine a direct relationship between DM with clinical improvement of PCOS due to certain limitations such as the relatively small sample size and the cross-sectional nature of the study, although it highlighted the formation of a homogeneous group for better comparison along with the inclusion of nutritional and cardiometabolic parameters, providing a better characterization of metabolic risk in PCOS. This study used PhA as a complementary marker to evaluate the clinical severity of the syndrome, although different inflammatory markers, which are quite relevant in PCOS, were not taken into account. We found an association between lower adherence to DM and worse metabolic and hormonal parameters in women with PCOS, emphasizing that better adherence to DM has benefits for body composition and reduces the severity of disease symptoms in women with PCOS. Mei et al. (13) highlighted the effectiveness of DM combined with a low-carbohydrate diet as a treatment for women with PCOS and overweight. Observing significant improvements in body composition, metabolic and hormonal markers, with notable benefits in the regulation of the menstrual cycle and the reduction of blood glucose and lipid parameters. Despite these findings, low continuity in dietary adherence by patients and cultural dietary constraints suggest that strategies are needed. In the study by Wang et al. (14) found a direct relationship between lower inflammation in women with PCOS and DM. DII was used to assess inflammation, observing improvements in inflammation and cardiovascular health, commonly compromised in the syndrome, associating DM as a protective factor against PCOS. Other studies, although they yielded less relevant results due to the methodologies used and the parameters measured, proved to be decisive in providing relevant information for the analysis of the Mediterranean diet.

The study by Mu L. et al. (15) did not find clear results on the direct relationship of DM with PCOS. Nutritional status and cardiometabolic indices were also not taken

into account, thus the study factors were incomplete. The study by Barrea et al. (12) developed a more complete evaluation, which was able to make a more direct comparison, with the presence of specific criteria. We observed what was predicted by previous studies, as MUO-SOP patients presented worse analytical values and lower adherence to the diet compared to MHO patients. Cutillas-Tollin et al. (11) did not find a clear association between DM and the presence of PCOS, which does not mean that there is no direct relationship, since the study also compared other dietary patterns. It showed a protective effect, highlighting the improvement of metabolic and hormonal indicators through DM, however these results were not very significant. The use of FFQ as a method of evaluation was not considered the most appropriate because of its greater biases and lack of precision.

Table 2. Mediterranean diet treatment studies in women with PCOS**.**

Author, year and reference	Type of study	Population	Features	Exclusion and inclusion criteria	Results
Barrea et al.2019, (10)	Observational cross-sectional case-control study	224 women in total (112 women diagnosed with PCOS and 112 in the control group)	Study of adherence to the Mediterranean diet. Assessment of dietary adherence, dietary intake and body composition, clinical severity and testosterone levels. These were assessed through the PREDIMED study, BIA, PhA and the Ferriman-Gallwey hirsutism score scale. Place of origin: Italy	Inclusion criteria: premenopausal, overweight or obese, age between 18 and 40 years, no underlying metabolic or metabolic disease, diagnosis of PCOS. Exclusion criteria: Menopause, hyperandrogenism, systemic or psychiatric disease, use of drugs that affect metabolism, hypocaloric diet in the last three months, use of drugs that influence water balance, pacemakers or defibrillators.	Women with PCOS presented lower adherence together with a lower consumption of basic foods in DM (EVOO, legumes, fish or nuts).
Mu L. et al. 2019, (15)	Clinical trial	3551 women of reproductive age with PCOS	Study on the prevalence of PCOS in metabolically healthy obese (MHO) versus metabolically unhealthy obese (MHO) women. Assessment of the metabolic risk profile through a large epidemiological survey, physical examination (BMI, blood pressure,	Inclusion criteria: diagnosis of PCOS through the Rotterdam criteria, being of childbearing age. Exclusion criteria: Menopause	No significant differences in BMI were found between the two PCOS groups.

			glucose and lipid profile) and transvaginal ultrasound. Place of origin: China		
Barrea et al., 2021(12)	Cohort study	94 women with polycystic ovary syndrome and obesity	Differential study to determine metabolic health status in PCOS according to phenotypes metabolically healthy obese (MHO) and metabolically unhealthy obese (MUO). Assessment of endocrine-metaboli c profile, inflammatory status, adherence to DM and body composition. Place of origin: Italy	Inclusion criteria: diagnosis of PCOS, BMI $\geq$30.0 kg/m ^{2}, fertile age between 18 to 30 years, same geographic area (Naples, Campania, Italy), no previous treatment. Exclusion criteria: BMI less than 30, menopause, lactation or pregnancy, psychiatric disease, treatment for metabolic activity, hypocaloric diet, dietary supplements, underlying metabolic disease, pacemakers or defibrillators, skin damage in the area of BIA application.	MUO patients presented higher CRP, testosterone and insulin levels, with lower adherence to DM and lower PhA. With a worse endocrine and metabolic profile compared to MHO patients.
Cutillas-T ollin et al., 2021(11)	Case-control study	121 women with polycystic ovary syndrome and 155 women as controls	Study on the associations between compliance with different dietary indices and the presence of polycystic ovary syndrome. Evaluation through anamnesis and semi-quantitative food frequency questionnaires (FFQ), physical examination, transvaginal ultrasound and blood collection, between days 2 to 5 of the menstrual cycle. Use of the PREDIMED test to assess adherence. Place of origin: Murcia (Spain)	Inclusion criteria: fertile age between 18 and 40 years, diagnosis by Rotterdam criteria. Exclusion criteria: pregnancy or breastfeeding, oncological treatment, hormonal medication during the three months prior to the study, genitourinary prolapse or endocrine disorders, medication that interferes with carbohydrate metabolism, hormonal contraceptives and thyroid hormones.	No clear association was found between the dietary indices studied together with PCOS and their phenotypes.
Wang et al., 2022(14)	Case-control study	527 women with polycystic ovary syndrome	Study on the association of PCOS-specific dietary patterns and quantification of possible inflammatory effects of diet. Evaluation of dietary		Inflammation was reduced by up to 4.79%, positively correlating diet with PCOS.

			inflammatory index (DII), dietary pattern and risk estimation through logistic regression and partial correlation analysis. Place of origin: China		
Mei et al. 2022 (13)	Randomized controlled clinical trial	59 overweight women with polycystic ovary syndrome. 29 in the LF diet group and 30 in the MED/LC diet group	Duration of 12 weeks. Study on the therapeutic effect of a Mediterranean diet (MED) combined with a low-carbohydrate (LC) dietary model in women with PCOS and overweight to achieve long-term metabolic improvement by reducing the intake of foods with trans fatty acids. Evaluation of weight, BMI, waist circumference, waist-to-hip ratio, body fat percentage, insulin, fasting plasma glucose, cholesterol, triglycerides, total testosterone, luteinizing hormone, as anthropometric indicators, reproductive endocrine levels, degree of IR and lipid metabolism levels. Place of origin: China	Inclusion criteria: diagnosis of polycystic ovary syndrome according to Rotterdam criteria, age 16 to 45 years, BMI ≥24.0 kg/m2. Exclusion criteria: endocrine disorders, combination of cardiovascular and cerebrovascular diseases, hematological disorders, hepatic or renal failure, pregnancy or lactation period, absence of contraceptives during the intervention period, mental illness, cancer, hormonal drugs other than progesterone or insulin sensitizers.	No side effects were observed during the intervention throughout the study. No differences were observed between the two groups with respect to age, anthropometry, sex hormone levels and blood biochemistry. 72.4% (21/29) of the patients in the LF group returned to normal menstrual cycles and 86.7% (26/30) of the MED/LC patients returned to normal menstrual cycles, with no significant differences between the two groups. Both groups showed a significant decrease in fasting insulin levels (FINS), HOMA-IR index, QUICKI index and lipid parameters (TG, TC and LDL-C), while HDL-C levels did not change significantly. In the MED/LC group, the reduction in blood glucose was more significant, also had a greater decrease in FPG, FINS, HOMA-IR and QUICKI. It also showed greater reductions in TG, TC and LDL-C, but not in HDL-C. As for FSH and PRL levels, a slight change was observed in both groups.

Finally, the discussion of the studies related between low glycemic index diet and PCOS will be developed. These are detailed in Table 3. Some of the studies (16,17) were conducted as a focus on overweight and obese women, emphasizing hypocaloric diets.

Results were obtained in the reduction of body weight, BMI and improvements in the values associated with the lipid profile. Hoover et al. (16) presented results at the hormonal level, ghrelin and glucagon, which were not very significant. Although the changes defined were consistent throughout the study, they were not specific to the diet studied, with no notable differences in the analytical values. The lack of assessment of insulin and blood glucose, very relevant parameters in PCOS, is noteworthy. The study by Camerlingo et al. (17) showed similar analytical results without significant changes.

In the study developed by Shishehgar et al. (18) found relevant improvement in the population studied. Clinical reflected in cycle irregularity was improved in 80% of cases along with a reduction in IR, although both were associated with weight loss. The study showed a better adherence with a dropout rate of 15%, since it was determined to be one of the few studies that promoted healthy lifestyle habits beyond a hypocaloric diet. Although inflammatory markers and lipid profile, markers of great relevance in PCOS, were not evaluated. In contrast, the comparative study by Panjeshanin et al.(19) although it presented improvements in certain values, did not find a significant relationship between the low GI dietary pattern and PFS.
Szczuko et al. (20) identified the low-GI diet as a useful dietary strategy to improve the antioxidant profile in women with PCOS. Observing an increase in uric acid levels and antioxidant activity, which could improve antioxidant status and benefit parameters such as weight and reduction of oxidative stress in these women. It is important to carefully monitor these levels to avoid the risk of inflammation and other health problems.

Table 3. Studies on low glycemic index diet treatment in women with PCOS**.**

Author, year	Type of study	Study population	Features	Exclusion and inclusion criteria	Results
Shishehgar et al., 2019(18)	Intervention study	62 women in total (28 women with PCOS and 34 women as controls)	Duration of 24 weeks. Study of low glycemic index (LGI) diet and energy restriction to compare their effects on anthropometric variables and IR. Assessment at baseline, 12 weeks and at the end of the study of anthropometric, biochemical, hormonal and clinical measurements, evaluation of hirsutism through the modified Ferriman-Gallwey scoring method. Place of origin: Iran	Inclusion criteria: Diagnosis of PCOS through the Rotterdam criteria, fertile age between 18-40 years, BMI >20. Exclusion criteria: pregnant women, breastfeeding, use of insulin-sensitizing agents or lipid-lowering therapies, contraceptives in the previous 6 months, hypocaloric diets, antihypertensives, antipsychotics, hormonal drugs, mental or chronic illness, participation in	Weight loss values of 8%, with virtually no differentiation between PCOS and non-PCOS cases. RI was not reduced in any group. Women with PCOS had reduced levels of total testosterone and FAI. Along with an increase in SHBG. Cycle irregularities in PCOS improved by 80% with a reduction in acne occurrence of 32.1%.

				previous similar studies.	
Panjeshani n et al. 2020 (19)	Case-contr ol study	216 women in total (108 women with PCOS and 108 women as controls)	Duration of 14 months. Study of the relationship of major dietary patterns in Iranian women with PCOS. Evaluation of the percentage of total and visceral fat mass. Place of origin: Iran	Inclusion criteria: diagnosed PCOS according to Rotterdam criteria.	No direct relationship was found between the dietary patterns studied and the presence of PCOS. The low glycemic index diet showed an improvement in the analytical results but was not representative.
Hoover et al., 2021(16)	Randomize d crossover clinical study	30 women with polycystic ovary syndrome	Duration of 20 weeks. Study of a low glycemic load diet versus a high glycemic load diet. Evaluation of postprandial parameters of ghrelin, glucagon glucose, insulin and appetite. Oral glucose tolerance test to rule out diabetes.	Inclusion criteria: diagnosis of PCOS, fertile age between 21 to 50 years, BMI $\leq$ 45 kg/m ^{2}, no weight fluctuations > 2.3 kg in the last 6 months. Exclusion criteria: intense exercise, diabetes, pregnancy, lactation, drugs affecting metabolism, food allergies.	The low glycemic load diet caused some reduction in postprandial glucagon and ghrelin in women with PCOS.
Camerlingo et al., 2022(17)	Randomize d clinical trial	40 overweight and obese women with polycystic ovary syndrome (21 of the women with hypocaloric diet and 19 of the women with hypocaloric diet together with Lactobacillus rhamnosus supplementatio n)	Duration of 20 weeks with monitoring every 4 weeks. Study of how intestinal bacterial abundance and lipid profile in a hypocaloric diet, with a 600 kcal deficit, affect changes in fecal short-chain fatty acid (SCFA) content. Evaluation of SCFA, selected intestinal bacteria (Akkermansia muciniphila, Bifidobacterium longum and Faecalibacterium prausnitzii), lipid profile and anthropometric parameters (body weight, waist circumference and fat mass), calculation of glycemic index values using the international glycemic index table and glycemic load.	Inclusion criteria: diagnosis of PCOS according to Rotterdam criteria, overweight/obese women, fertile age between 18 and 45 years, no previous ovarian surgeries. Exclusion criteria: pregnancy or breastfeeding, taking antibiotics or probiotics in the last 6 months, hormones that could affect the menstrual cycle in the last 3 months, drugs that affect carbohydrate metabolism, weight loss supplements, anti-inflammatory or nutraceutical drugs, thyroid	Body weight, BMI, fat mass, acetic and butyric acids were reduced and lipid profile (total cholesterol, low-density lipoprotein cholesterol and triglycerides) improved in both groups. No conclusive results were found with the use of supplementatio n or changes in SCFA levels in either group.

				disorders, hyperprolactinemia, Cushing's syndrome, liver, kidney, cardiovascular or digestive disease.	
Szczuko et al.2019 (20)	Intervention study	24 overweight and obese women with polycystic ovarian syndrome	Duration of 3 months. Study of low GI hypocaloric diet to determine which antioxidants increase their activity with exogenous antioxidant and essential fatty acid (EFA) supplementation to suppress inflammation. Evaluation of glutathione peroxidase (GPx3) activity, plasma iron-reducing capacity and uric acid concentration. Anthropometric measurements were assessed by BIA. Testosterone, insulin and SHBG were assessed by ECLIA (electrochemiluminescence immunoassay) and and androstenedione was analyzed by ELISA (Kobas Rosch E411). Glucose was analyzed by an enzymatic method with hexokinase. Place of origin: Poland	Inclusion criteria: diagnosis of PCOS according to Rotterdam criteria**.** Exclusion criteria: Women diagnosed with hyperprolactinemia, congenital adrenal hyperplasia, Cushing's syndrome, androgen-releasing tumor and acromegaly.	Increases in uric acid and GPx3 activity were observed, a significant correlation was observed between GPx3 and prolactin, fasting insulin and triglycerides. Antioxidant status did not change significantly. No significant correlation was observed between uric acid and FRAP. But if between uric acid level and increased PRL and fasting glucose, also in people with lower body mass, lower BMI and lower total body water.

Discussion and conclusions

At the end of the study on the three dietary patterns as a treatment for polycystic ovary syndrome (PCOS), the ketogenic diet, the Mediterranean diet and the low glycemic index diet, it is concluded that these can be beneficial depending on the aspects to be treated, observing as an important common factor a healthy lifestyle. Although there is still a large uninvestigated field, advances in recent years have given more relevance to the syndrome.

All the hypocaloric diets analyzed are effective for women with PCOS who are overweight and obese, thus improving the associated symptoms. .

The ketogenic diet is considered beneficial in the short term for weight loss, improving parameters that are directly associated with obesity and overweight. Considering in the same way that they present low adherence due to their highly restrictive nature.

The Mediterranean diet is considered less efficient in short-term studies against specific parameters, although it improves various aspects of general health. They present less restrictive characteristics, focused on quality of life and a healthy lifestyle. It is one of the diets with the highest long-term adherence, offering improvements in practically all levels compared.

The low glycemic index diet presents inconclusive results in terms of specific benefits for PCOS, in addition to being highly restrictive. Most of the studies are predominantly from Western countries, which influences the results mainly due to dietary cultural factors.

The combination of dietary patterns improves the quality of the treatment, according to the needs and symptomatology, adapting in the best way to the patient and offering different benefits.

These findings provide a balanced, evidence-based view of how different dietary patterns can be used in the treatment of PCOS. Concluding that the diets presented have great bearing on the treatment of PCOS, offering different approaches and benefits.

It is crucial to study more about the long-term repercussions of highly restrictive and hypocaloric diets in PCOS patients, as it is currently presented in a negative way but there is a lack of studies to support it.

More intervention studies are needed to directly relate the Mediterranean diet and PCOS, as there is not much evidence in this regard, as a dietary pattern with high therapeutic potential and not only as a habit improvement.

The efficacy of the dietary patterns analyzed in women with PCOS without overweight and obesity should be further studied. So far, there is little evidence that these diets work as a treatment for any woman diagnosed with PCOS.

Further studies are needed to determine whether the results found are sustained over time across all diets, as women with PCOS have a higher prevalence of weight gain along with associated long-term pathologies and symptoms, which could be prevented with appropriate dietary patterns.

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PERCEPTION OFthe risk of type 2 diabetes mellitus in young adults aged 20-39 years in the department of Guatemala

Perception of the risk of suffering type 2 diabetes mellitus in young and adults aged 20-39 in the department of Guatemala

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SUMMARY

Diabetes mellitus is a chronic metabolic disease with a high social and economic impact worldwide and nationally. The purpose of this study was to identify the population's perception of the risk of suffering type 2 diabetes mellitus in the future, a situation that had not been evaluated in the country. This is a quantitative, cross-sectional and descriptive study, using an electronic survey, shared through social networks initially, selecting people who had family members or worked with people within the age range of the study and who were asked to share their experiences with the study. It allowed to know the perception that the population between 20 and 39 years of age in the department of Guatemala has about suffering from diabetes in the future, the main risk factors and proposals, on the part of the population, for prevention. It was carried outduring November 2023, with a sample of 76 people, 68% women, with an average age of 29.95 years. The results showed that 45% of the population perceived themselves to be at risk for diabetes. The main factors identified that predispose the population surveyed to diabetes are: 75% of family members with diabetes mellitus, not exercising 48%, overweight and obesity 63%, infrequent consumption of fruits and vegetables, as well as lack of knowledge of blood pressure values. Suggestions for reducing risk included improving access to information, making use of social networks, implementation of healthy spaces, health services focused on prevention, and state policies aimed at preventing chronic noncommunicable diseases. It was recommended that surveys be conducted on the perception and dissemination of the main risk factors for diabetes mellitus, with the aim of generating awareness and evidence to improve access to information for the country's population.

RESUMEN

Palabras clave:
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Diabetes, prevención, percepción de riesgo, diabetes en Guatemala, factores de riesgo.

La diabetes mellitus es una enfermedad metabólica crónica, con un alto impacto social y económico a nivel mundial y nacional. Con la finalidad de identificar la percepción que tiene la población sobre el riesgo de padecer diabetes mellitus tipo 2 en un futuro, situación que no había sido evaluada en el país. El presente es un estudio cuantitativo, transversal y descriptivo, utilizando encuesta en formato electrónico, compartida por redes sociales a conveniencia inicialmente, seleccionando personas que tenían familiares o trabajaban con personas comprendidas dentro del rango etario de estudio y a quiénes se les solicitó compartir. Permitió conocer la percepción que tiene la población entre los 20 y 39 años del departamento de Guatemala sobre padecer diabetes en un futuro, los principales factores de riesgo y propuestas, por parte de la población, para la prevención. Fue realizado durante noviembre 2023, con una muestra conformada por 76 personas, 68% mujeres, con media de edad en 29.95 años. Los resultados demostraron que el 45% de la población se percibió en riesgo de padecer de diabetes. Los principales factores identificados y que predisponen a la población encuestada a padecer de diabetes son: familiares que padecen de diabetes mellitus en un 75%, no practicar ejercicio 48%, el sobrepeso y obesidad 63%, poca frecuencia del consumo de frutas y verduras, así también, el desconocimiento de los valores de la presión arterial. Como parte de las sugerencias para reducir el riesgo se planteó mejorar el acceso a la información, haciendo uso de redes sociales; implementación de espacios saludables, servicios de salud con enfoque en prevención y políticas de estado orientadas a la prevención de enfermedades crónicas no transmisibles. Se recomendó realizar encuestas sobre la percepción y dar a conocer los principales factores de riesgo de padecer de Diabetes mellitus, con la finalidad de generar conciencia y evidencia para mejorar el acceso a la información de las personas del país.

Introduction

Diabetes Mellitus type 2 is characterized as a chronic non-communicable metabolic disease, which corresponds to a high level of circulating glucose in the bloodstream. As of 2010, there were 2.4 million people with diabetes in Central America, with an increase to 3 million by 2019. It is estimated that by 2045 there will be an increase to 5.6 million by 2045 among those aged 20 to 79 years. The consequences of the disease have a direct impact on the quality of life of individuals and their families, associated with complications such as heart failure, nephropathy, retinopathy, neuropathy, amputations and an increase in premature deaths, being the second most frequent cause of premature death and disability in Central America (1).

The increase in the number of young people with chronic noncommunicable diseases is a cause for concern. According to WHO/PAHO, 10.3% of women and 8.9% of men over 18 years of age in Central America and the Dominican Republic have high blood glucose or diabetes (2) (2). As a consequence of this phenomenon, the expenses incurred by Central American countries for treatment amounted to USD$8,842 million in 2015 (1). As a consequence of this phenomenon, the high expenditures incurred by Central American countries for treatment amounted to USD$8,842 million in total, including direct and indirect expenses, during 2015 (1).

In the case of Guatemala, the direct cost associated with Diabetes was USD$1,385 per capita in the conservative scenario and USD$462 per capita expenditure, which is 6 times higher than in 2000 (2). In addition, a progressive increase in the number of cases diagnosed with diabetes mellitus was identified since 2008 with 47,511 diagnoses, compared to the year 2022 when 147,631 people were diagnosed. During the year 2022, the diagnosis increased in the 40 and older age groups, especially in women, with a 3:1 ratio with the highest risk in the northern and eastern region of the country (3-5).

When analyzing the years of life potentially lost between 2010 - 2020, the impact is greater in women, however, by 2020 it increased in both sexes compared to previous years. In relation to age, there is an increase in mortality after 40 years of age, with a maximum peak at 45 years of age. The sum of the years lost in 2019 is 56,508 and for 2020 81,982. In addition, the relative risk of dying from diabetes mellitus compared to cardiovascular disease is 5 times higher (4).

It is internationally recognized that among the main risk factors related to diabetes are sedentary lifestyle, poor eating habits, as well as hereditary risk factors. Therefore, actions should be oriented to prevent the development of type 2 diabetes according to evidence (6).

The perception that a person may have in relation to suffering in the future from Diabetes Mellitus is subjective, it will depend on the access to information that the person has had during his life, the meaning that this may have or the analysis that has been performed (7). This perception is also associated with the impact or meaning it has had on their life, such as the amputation of a limb or death of a family member.

Since 2003, the FINDRISK test (Finnish Diabetes Risk Score) was proposed to identify the risk of developing diabetes, which was later modified for Latin America (FINDRISK LA) and was based on the results obtained in the study of the same name, where risk factors were identified without the need for laboratory tests. The usefulness of the test is to predict the risk of developing Diabetes mellitus in 5 to 10 years. This test has been validated in different countries, such as Venezuela, Colombia, Peru and has also been used in Guatemala (8-11) (8-11).

In the Hospital de Jutiapa, Guatemala, the FINDRISK test was used to estimate the risk of developing type 2 diabetes mellitus in outpatients, where it was identified that

51.8% of women presented moderate to very high risk and men low or slightly high risk, as well as those under 45 years of age, concluding that it is necessary to define prevention strategies to reduce the risk (10).

The perception of people in the country regarding the possibility of suffering from diabetes or the actions they take to prevent it is not known. This study aimed to identify the perception that people between 20-39 years of age in the department of Guatemala have in relation to suffering from type 2 diabetes in the future, the main risk factors and proposals by the participants on interventions to reduce the risk.

In the country, the perception that people have regarding the possibility of suffering from diabetes or the actions they take to prevent it is not known. The present study aimed to identify the perception that adults between 20-39 years of age in the department of Guatemala have regarding the possibility of suffering from type 2 diabetes in the future.

Therefore, the study will provide a strategic vision to health personnel on the perception that people between the ages of 20-39 years may have about the prevention of diabetes or the risk that each of them may present about the risks associated with the development of this disease.

Method

Research design:

The research was developed with a quantitative, cross-sectional methodology, through the application of a survey in electronic format elaborated with Google Forms and shared by convenience to actors with relatives or with access to people within the age range of the study and requesting to share with other contacts through social networks to people in the department of Guatemala.

Population and sample:

The universe of the study is made up of people between 20 and 39 years of age in the department of Guatemala, considering that this is a population in which interventions for diabetes prevention should be developed (9,12).

Taking into consideration the national statistics of the department of Guatemala, located in the central zone, one of the departments with the greatest economic development, and with the highest number of diagnosed cases of diabetes during the year 2021 (13). It has 17 municipalities with a total population estimated at 3,639,725 for the year 2023 (4). The population between 20 and 39 years of age for the year 2023 was 1,255,485 for both sexes, corresponding to 34.5% of the total estimated population for the department, of which 51.4% (644,939/1,255,485) are women (4). From this finite universe, a probabilistic sample was calculated, using the tool proposed by the European University of the Atlantic, with a confidence index of 95% of representativeness (14).

The sample approach was through a survey, elaborated in Google Forms and sent by convenience to stakeholders with relatives or with access to people within the age range of the study and requested to be shared with other contacts through different social networks such as WhatsApp or Facebook and requested to different stakeholders, among which university professors can be mentioned, to share it with their students.

Inclusion criteria were:

a. People between 20 and 39 years of age
b. Persons who voluntarily agree to fill out the survey electronically
c. People living in any of the 13 municipalities of the department of Guatemala. A filter for these people was included in the survey that discriminates against people residing in other departments.

Among the exclusion criteria, the following were considered:

a. People diagnosed with Diabetes Mellitus

The population reached with the research was a total of 123 people, which after applying the inclusion and exclusion factors left 76 people, who were considered within the sample.

Measuring instruments and techniques

In order to analyze the main factors that predispose to diabetes mellitus, the "Latin American Finnish Diabetes Risk Score -LA FINDRISK- scale was used as a guide, detailing the main factors within the survey and finally to quantify the score according to the parameters proposed by the scale, which was compared with what was indicated by the participants as self-perception (8).

Procedures

We began with a literature review on the prevention, risk factors and possible strategies for the prevention of type 2 diabetes mellitus. Epidemiological information from Guatemala related to the disease was reviewed and analyzed, as well as the cost of the care of this disease and what it may imply at the national level.

With the information obtained, the question was posed: is the population aware of or do they identify themselves as being at risk for diabetes mellitus? Taking into consideration that the risk of suffering it increases from the age of 40 onward (12). At the same time, the question was posed: How to identify the perception of risk of suffering from diabetes? According to the documentary review, the FINDRISC LA test was identified (8) to measure the risk of suffering from diabetes. The general objective was to determine the perceived risk of developing type 2 diabetes mellitus in people between 20 and 39 years of age. Subsequently, the semi-structured survey was constructed in digital format with Google Forms, a QR code was generated and an electronic link through which the survey was shared.

The survey was completed voluntarily and virtually, and was available from October 28 to November 30, 2023, with data entry monitored every two days.

The information obtained was cleaned and tabulated in an Excel spreadsheet where pivot tables were created for analysis. With the tabulated information, statistical analysis was carried out using "R study" and prevention strategies were proposed according to what was contributed by the participants.

Statistical analysis

The statistical analysis of the study was performed at three points in time:

a. Descriptive statistics of the sample: to characterize the sample, a simple table of frequencies and grouping by five-year period in relation to age was made using Excel statistical analysis, with which the mean, median, variance and standard deviation were calculated. With the information obtained, the behavior of the sample was calculated with the "R" and "R study" programs, as well as with the

online descriptive statistics calculator - DATAtab and the online descriptive statistics calculator Mathcracker.com. For the analysis of the sample, percentages and bivariate comparison between sex and each of the demographic variables included in the study were obtained in an Excel spreadsheet.

b. Analysis of risk factors for diabetes mellitus: comparative tables were generated in an Excel spreadsheet, with which multivariate analysis was performed by sex and each of the factors, defined as independent variables and the number of people by sex as dependent variables. The analysis was complemented with the calculation of Odds Ratio (OR) and relative risk (RR) to identify the correlation of the results between self-identified groups with and without risk of diabetes, as well as the calculation of the range according to the 95% confidence index.
c. To generate the different interventions and improve access to information, an Excel spreadsheet was used to classify the different interventions suggested by the study population and integrated according to intervention affinity.

Results

The sample included a total of 76 people, of whom 68% (52/76) were women. Participants ranged in age from 20 to 39 years, with a mean of 29.95 years, variance of 31.25, standard deviation of 5.59 and standard error of 0.6458.

In Table 1 we can see the detail of the sociodemographic variables, where 66% of the total population surveyed was single, 91% belonged to the mestizo people, 91% were originally from the department of Guatemala, 51% lived in the municipality of Guatemala, 45% were university students, 39% worked as professionals or technicians in similar proportion, as we can see in Table 1.

Table 1.

Sociodemographic variables of the study population classified by sex.

Marital status	**Men % Men % Men % Men % Men % Men % Men % Men % Men**	**Women % Women**	**Total**
Single	19 (38%)	31 (62%)	50 (66%)
Married	3 (17%)	15 (83%)	18 (24%)
De facto union	2 (29%)	5 (71%)	7 (9%)
Divorced	0 (0%)	1 (100%)	1 (1%)
Town	**Men % Men % Men % Men % Men % Men % Men % Men %**	**Women % Women**	**Total**

	Men % Men % Men		
Maya	1 (14%)	6 (86%)	7 (9%)
Mongrel/ladino	23 (33%)	46 (67%)	69 (91%)
Department of origin	**Men % Men % Men % Men % Men % Men % Men % Men % Men % Men**	**Women % Women**	**Total**
Guatemala	21 (30%)	48 (70%)	69 (91%)
Another	3 (43%)	4 (57%)	7 (9%)
Municipality of residence	**Men % Men % Men % Men % Men % Men % Men % Men % Men % Men**	**Women % Women**	**Total**
Amatitlán	0 (0%)	8 (100%)	8 (11%)
Guatemala	11 (28%)	28 (72%)	3 (51%)
Mixco	5 (56%)	4 (44%)	9 (12%)
Palencia	1 (33%)	2 (67%)	3 (4%)
San José Pinula	0 (0%)	1 (100%)	1 (1%)
San Juan Sacatepéquez	1 (25%)	3 (75%)	4 (5%)
San Miguel Petapa	2 (40%)	3 (60%)	5 (7%)
Villa Nueva	4 (57%)	3 (43%)	7 (9%)
Education level	**Men % Men % Men % Men % Men % Men % Men % Men % Men % Men**	**Women % Women**	**Total**

Basic	2 (67%)	1 (33%)	3 (4%)
Diversified	5 (17%)	24 (83%)	29 (38%)
University	13 (38%)	21 (62%)	34 (45%)
Master's degree or Ph	4 (44%)	5 (56%)	9 (12%)
Occupation	**Men % Men % Men % Men % Men % Men % Men % Men % Men % Men**	**Women % Women**	**Total**
Housewife	0 (0%)	7 (100%)	7 (9%)
Technicians	9 (30%)	21 (70%)	30 (39%)
Professionals	9 (30%)	21 (70%)	30 (39%)
Students	4 (57%)	3 (43%)	7 (9%)
Unemployed	1 (100%)	0 (0%)	1 (1%)
Military	1 (100%)	0 (0%)	1 (1%)

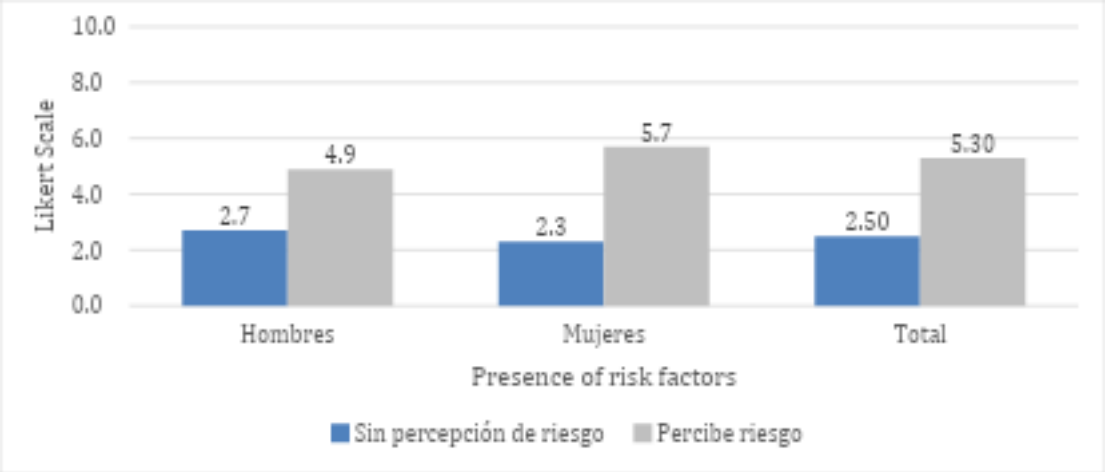
Perceived risk of diabetes mellitus:

People's perceptions were obtained through responses to the question: are you considered at risk for diabetes mellitus? To this question, 55% (42/76) of people responded that they did not consider themselves to be at risk. When comparing the perception of risk by sex, it was identified that 58% (14/24) of all men and 54% (28/52) of women indicated that they were not at risk for diabetes.

A Likert scale was used to determine the degree of perceived risk of suffering from diabetes mellitus in the persons surveyed, where 0 presented no risk and 10 as high risk. With the data obtained, a comparison was made by sex, as shown in Figure 1, with a higher average risk perception in the case of women compared to men.

Figure 1.

Perceived risk of diabetes mellitus within the study population by sex.



In order to stratify the risk obtained with the Likert scale, it was divided into 4 sections, where people who indicated 0 were classified as no risk, 1 to 3 as low risk, 4 to 6 as medium risk and 7 to 10 as high risk. Sixteen percent (12/76) indicated no risk of diabetes, 30% (23/76) low risk, 39% (30/76) medium risk, and 14% (11/76) high risk of diabetes. (See Figure 2). The average stratification score was 3.79 or at low risk for diabetes.

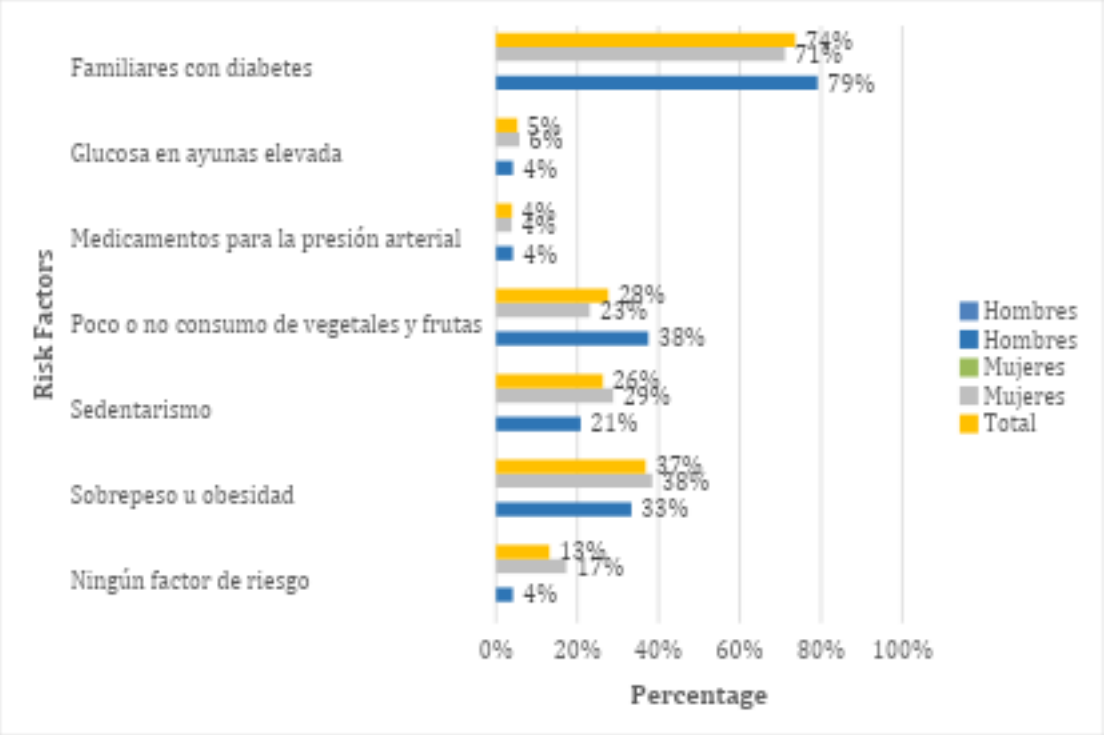
Figure 2.

Perception of the level of risk of diabetes mellitus within the study population.

The main risk factor identified by the study population was having family members with diabetes, equivalent to 74% of the total number of people. The second factor identified was overweight or obesity in 37%. In third place was the little or no consumption of vegetables and fruits with 28%, followed by a sedentary lifestyle with 26%. (See Figure 3).

Figure 3.

Risk factors for diabetes identified by the study population.



A comparison of the results obtained for risk factors by sex showed that men acknowledged having family members with diabetes and little or no consumption of vegetables and fruits, exceeding the mean of the total responses obtained. In the case of women, they identified higher risk related to sedentary lifestyle and overweight or obesity and elevated glucose levels compared to men.

Of the total study population, 64% (49/76) had one or two risk factors, including 79% (19/24) of men and 58% (30/52) of women. Eighteen percent (14/76) reported 3 to 4 risk factors and 4% (3/76) more than 5 risk factors.

Risk factors for diabetes:

When analyzing the results of the survey with the FINDRISK LA test on the risk of developing diabetes mellitus in the next 10 years, an average of 7.82 points was obtained, which places the surveyed population in the low risk range. Twelve percent (9/76) of the total population had a risk above 12 points for the FINDRISK LA scale, which places them at moderate or high risk. With the self-perception scale, we were able to locate 14% (11/76) of the population at high or very high risk.

When comparing the average obtained with the FINDRISK-LA questionnaire with the result of self-perception, with an average of 3.79 points, both results coincide in the range of low risk for diabetes.

When going deeper into the questions for the correct filling of the FINDRISK-LA scale, 3% (2/76) of people without risk factors were identified, compared to 16%

(12/76) obtained with the self-perception of risk, being the Body Mass Index measurement the one that confirmed the detail of overweight that was not self-perceived.

Table 2 shows the main risk factors identified in the population that predispose to type 2 diabetes mellitus. In this study, we were able to identify a higher percentage of family members with diabetes mellitus (75%), being higher in those who were identified as having risk factors, for a RR of 1.28 (95%CI 0.95-1.73). Sixty-three percent of the population did not exercise, with an RR of 0.88 (95%CI 0.52-1.50). Overweight and obesity together account for 63%, with a greater presence in those who identified themselves as being at risk.

Ignorance of blood pressure was present in 42% with a RR of 0.42 (95%CI 0.23-0.75), being mostly in the population that did not identify themselves as being at risk for diabetes. A similar situation occurred with the lack of knowledge of blood glucose measurement, with 37%, being higher in the population that was not identified as being at risk.

Table 2.

Risk factors for diabetes mellitus identified by number, percentage and relative risk.

Risk Factors	Quantity	%	OR	Relative risk	RR Range 95% CI		P
					Menor	Mayor	
Family members with diabetes	57	75%	2.90	1.28	0.95	1.73	0.5
No exercise	48	63%	0.71	0.88	0.52	1.50	0.8
You do not know your blood pressure	36	47%	**0.19**	**0.42**	**0.23**	**0.75**	**0.5**
Fruit consumption less than twice a week	35	46%	2.06	1.47	0.83	2.60	0.7
Overweight	31	41%	1.6	1.32	0.65	2.68	0.5
Unknown glucose levels	28	37%	4.03	0.49	0.24	1.01	0.5
Less than 6 hours of sleep	27	36%	1.24	1.15	0.29	4.52	0.7

Consumption of refined sugar more than 3 times per week	25	33%	0.96	0.97	0.67	1.41	0.5
Consumption of vegetables less than twice a week	21	28%	1.17	1.12	0.01	95	0.7
Obesity	17	22%	**4.03**	**2.97**	**1.11**	**7.98**	**0.5**
Consumption of junk food more than 3 times per week	17	22%	2.87	2.26	0.83	6.14	0.6
More than 8 hours sitting	16	21%	3.54	2.72	0.96	7.68	0.5
He suffers from hypertension	8	11%	4.29	3.71	0.62	22.1	0.6
Fasting glucose elevated or greater than 110 mg/dl	6	8%	9.76	6.18	0.62	61.83	0.5

Acronyms: %: Percentage: OR: Odds Ratio; RR: Relative risk; 95% CI: 95% confidence interval; P: P value.

The consumption of refined sugar was higher than three times per week in 33% of the surveyed population. The consumption of futas was less than twice a week in 46% and was lower in people with risk factors with an RR of 1.47 (95%CI 0.83-2.60) compared to those who were not identified with risk factors. Vegetables were consumed less than twice a week in 28% of the population (see Table 2).

The factors documented with lower presence in the population were hypertension and glucose levels higher than 110mg/dl, with 11% and 8%, respectively. Both factors were present in people with risk factors for an RR of 3.71 and 6.18 respectively.

Interventions to reduce the risk of diabetes mellitus:

Within the main interventions raised by the respondents and with the aim of preventing diabetes were ordered as follows:

a. Improve access to information:

- Massive campaigns or educational days on Diabetes Prevention measures
- Raise awareness of the importance of healthy eating habits and lifestyles in accordance with the population
- Talks on healthy eating in the community and in educational centers, aimed at children and young people
- Sending personalized prevention messages

- Tools to know the risk of diseases, in a clear and understandable way
- Conduct surveys targeting the general population and segmented by age groups to raise awareness
- Education programs in educational centers for children regarding diabetes, including parenting schools

b. Healthy spaces:

- Public spaces to practice and encourage exercise.
- To develop healthy eating habits that meet the requirements and possibilities of each family.
- Nutrition education focused on local and easily accessible foods.

c. Health services with a focus on prevention:

- Provide talks in public spaces on self-care.
- Training for caregivers of people with diabetes to reduce the risk of complications.
- Education on healthy eating for people with diabetes and their families.

d. State policies aimed at prevention:

- State policies related to the restriction of the consumption of refined sugar and trans fats.
- Implement taxes on fast food and use them in campaigns to prevent diabetes and other chronic diseases.
- The country's health budget is oriented to the prevention of chronic diseases.
- Design strategies with a preventive approach for adults and the elderly.

The surveyed population recommended using social networks to share information related to diabetes prevention in 72% (55/76), through email with 39% (30/76), in third place, in public health services with 38% (29/76) and in private health services with 22% (17/76). In last place and with 4% (3/76), they recommended the use of communication by other mass media.

Discussion and conclusions

The present study was developed through the completion of a voluntary, virtual survey, shared access by electronic means, which is why it is oriented to a population with access to a mobile electronic device, with access to internet and definitely able to read and write. This explains the behavior of the population's educational level and occupation. In addition, the interview did not focus on the causes of the habits, the amounts of portions, the quality of sleep or the behavior adopted by the population, as this was not the focus of the present study, these being some of the limitations.

Studies in Guatemala associated with the risk of diabetes using the FINDRISK-LA scale did not include the population's perception of risk and were conducted in hospital settings (15). It was also approached in a community setting to people already diagnosed with diabetes (16). This is an advantage gained from the study, given that the subjects were not in clinical settings and were able to answer questions in a private setting. The main limitation of this action is that anthropometric measurements cannot be corroborated.

The population surveyed self-identified 45% at risk for diabetes, with the main risk factors being: having a family member with diabetes mellitus, being overweight, obesity and infrequent consumption of vegetables and fruits.

Seventy-five percent of the total population confirmed having family members with diabetes, as evidenced in previous studies (3,15-19) (3,15-19). This confirms that the experience previously presented with relatives implies a higher perceived risk of suffering from diabetes in the future. Genetics is a predisposing factor for diabetes that cannot be modified, however, with a healthy lifestyle, the development or onset of diabetes can be delayed and possible complications prevented. This is why it is important to provide tools and knowledge to the families of people with diabetes and to provide guidance on the need for early and periodic evaluation.

The mean Body Mass Index in the study population is 26.9, placing the population in overweight. Forty-one percent (31/76) of the total population was overweight, with a higher percentage in men (50%) and 22% obese, especially in those identified as having risk factors. This finding is similar to that reported by other authors for the country (10,20) (10,20)where there is a greater tendency of overweight in men and obesity in women. Knowledge of the BMI of the population can establish the possibility of risk of suffering from diabetes. With the surveyed population, it was confirmed that it was not taken into consideration in the perception by 13% of the population. Overweight and obesity are considered to be one of the main predisposing factors in insulin resistance and as such favor the development of type 2 diabetes, as well as cardiovascular conditions (24).

Daily fruit consumption was 14% (11/76) and daily vegetable consumption was 30% (23/76), comparable with the results presented by other authors (10,20) (10,20)is one of the situations that should be improved with the different public health interventions in the country. In addition, the consumption of fruits and vegetables is lower in men than in women, indicating an average of 32% for fruit and vegetable consumption (10). Diet is one of the main risk factors that can be modified and targeted for the prevention of diabetes. In this case the increase in natural fiber delays the absorption of sugar and as such the decrease of sugar in the bloodstream (25).

The consumption of junk food is present daily in 5% of the surveyed population, 17% consume it three to five times a week and 54% consume it once or twice a week. The consumption of refined sugar is higher than that of junk food with 8% of the total population consuming it daily, 25% three to five times per week and 46% once or twice per week. This habit should be reduced by offering different options to the population, with the availability of spaces for healthy eating, especially in the workplace. The type of food consumed, both for breakfast and dinner, is based on eggs, beans, sausages, bread or tortillas and coffee, as cited by other authors (20) (20). This is an area that needs to be worked on in the country, reorienting diets with higher vegetable and fruit content and avoiding processed foods can have a greater impact on diabetes prevention (25).

With regard to sedentary lifestyle, 42% of the population studied spent between 4 to 6 hours a day sitting and 21% spent more than 8 hours a day. In this sense, the implementation of safe spaces for physical activity and occupational health and safety strategies should ensure that active breaks are included in the workplace (6, 12, 24, 25).

Fifty-four percent of the surveyed population sleeps between 6 to 8 hours a day and 34% sleeps between 4 to 6 hours a day. The study did not include analysis of sleep quality and may be considered a topic of interest for further studies.

With regard to physical exercise, 37% of the total population studied indicated that they exercised, 42% more men than 35% women, 3% exercised daily and 17% 4 to 5 times a week. These results are similar to those of other authors who reported that 29.3% of the total population practiced exercise (3,10) (3,10).

Eleven percent of the total population surveyed suffers from hypertension, of which 75% are women. This information is striking, since 51% of the total number of people do not know their blood pressure figures and possibly among them there could be people with high blood pressure or undiagnosed hypertension, taking into consideration previous studies where it is stated that 23.8% of the population suffering from hypertension (10) (10). Furthermore, in Guatemala, mortality due to diseases associated with the circulatory system corresponds to 18% in women and 16% in men, according to the National Health Diagnosis for the year 2020 (21).

Of the total population, 63% (48/63) have had at least one glucose measurement, 65% of which corresponds to a medical check-up. Of the total number of people surveyed who have had their glucose measured, 13% (6/48) of the total population had elevated fasting glucose levels or higher than 110mg/dl, 83% of whom were women, a finding twice as high as that identified in the hospital in Jutiapa, Guatemala (10) (10). According to the Ministry of Public Health and Social Assistance, endocrine, nutritional and metabolic diseases are the second leading cause of death in women (15%) and 10% in men (21) (21).

54% of the total population surveyed presented low risk for developing Diabetes Mellitus according to the FINDRISK scale, a situation similar to that identified in other studies conducted in Guatemala in hospital settings with a score of 10.1 (10). When comparing this result with self-perceived risk, we identified that 39% of the population considered themselves to be at moderate risk and 30% at low risk of diabetes mellitus. This finding allowed us to identify a relationship between the self-perceived risk assessment and the FINDRISK scale for diabetes in a population between 20 and 40 years of age. This information can be used as part of strategies to raise awareness among the population in non-clinical settings (work, education or recreation) or in community spaces. Given that the survey was conducted within the population of the capital city and its municipalities, it is recommended that the opportunity be expanded to include the perception of the population in other departments of the country in future studies or analyses.

When analyzing the factors that predispose to diabetes, we identified the presence of high blood glucose levels, arterial hypertension, obesity and sitting for more than 8 hours as the highest relative risk factors in the surveyed population that indicated that they considered themselves at risk. In the case of people who did not identify themselves as being at risk, the factors associated with greater risk are not knowing their blood glucose levels, not knowing their blood pressure, not exercising, and the consumption of refined sugar.

With a p value of 0.5 for most of the risk factors, we can conclude that the sample population presents characteristics that can be identified within the general population, without being able to be conclusive with the result, which leads us to expand this type of study in different sectors and departments of the country and make comparisons with the behavior of the population.

Among the main actions oriented to improve the population's knowledge or measures to prevent diabetes mellitus, different actions have been proposed, which have been contained in proposals made by other authors (3,5,6,22,23)these actions include: improving access to information; healthy spaces or environments; health services with a preventive approach and state policies oriented to prevention.

In addition, it is considered that in work environments, actions associated with Occupational Health and Safety should be increased with the implementation of active breaks that allow workers to perform physical activity during working hours, health activities that include periodic measurements of weight, waist circumference, height, blood pressure and glucose levels. These actions also apply to training environments (schools, colleges, universities) and not only to those oriented to the health area.

In community settings, spaces should be provided where the population can come and take their weight, height, blood pressure or glucose levels in an accessible way and not limited to health services, as well as having information related to food, healthy diets and exercise for the population according to their age.

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Conflict of interest

I do not have any conflict of interest with the realization of the present study, it has been developed within the training process to obtain the Master's Degree in Public Health.

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Macronutrient intake distribution according to circadian rhythms to enhance weight loss in overweight and obese individualss

Distribución de la ingesta de macronutrientes según los ritmos circadianos para potenciar la pérdida de peso en individuos con sobrepeso y obesidad

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ABSTRACT

(The progression of obesity has emerged as a global health issue in recent years. In response, new nutritional approaches, such as synchronizing macronutrient intake with circadian rhytms, have been explored as potentially effective strategies for improving body composition and promoting weight loss. The aim of this study is to determine the best times of day to consume each macronutrient to optimize weight loss. To achieve this, an exhaustive bibliographic review was carried out, selecting and analyzing a total of 14 articles published in the last five years from the Pubmed database, along with using the Google search engine for official pages. The results suggest that the nutritional composition of meals and their consumption timing during the day are effective dietary strategies for weight loss. Although further research is needed for more precisely define the optimal times for the intake of each macronutrient, it can be concluded that consuming macronutrients at specific time of the day may be an effective nutritional strategy to improve body composition and promote weight loss in individuals with overweight and obesity.

Palabras clave:
Crononutrición, obesidad, pérdida de peso, macronutrientes y ritmos circadianos.

RESUMEN

La progresión de la obesidad ha resaltado como un problema de salud global en los últimos años. En respuesta, se han explorado nuevos enfoques nutricionales, como la sincronización de la ingesta de macronutrientes con los ritmos circadianos, que podrían ser estrategias efectivas para mejorar la composición corporal y promover la pérdida de peso. El objetivo de este estudio es determinar los mejores momentos del día para consumir cada macronutriente con el fin de optimizar la pérdida de peso. Para ellos, se realizó una revisión bibliográfica exhaustiva, seleccionando y analizando un total de 14 artículos publicados de los últimos cinco años en la base de datos de PubMed. Además del uso del buscador de Google para páginas oficiales. Los resultados sugieren que tanto la composición nutricional de las comidas como el momento de su

consumo durante el día son estrategias dietéticas efectivas para la pérdida de peso. Aunque se requieren más investigaciones para definir con mayor precisión los momentos óptimos para la ingesta de cada macronutriente, sin embargo, se puede concluir que consumir macronutrientes en momentos específicos del día puede ser una estrategia nutricional efectiva para mejorar la composición corporal y promover la pérdida de peso en individuos con sobrepeso y obesidad.

Introduction

Obesity, defined as the abnormal or excessive accumulation of fat, is a global public health problem caused by multiple factors (1–3).Despite efforts focused on traditional risks such as excessive energy intake and lack of physical activity, obesity rates have increased in recent decades (1,2,4)recently, new factors such as the nutritional composition of meals and circadian misalignment have been identified that may contribute to the development of obesity (5,6).

Circadian rhythms, present in mammals, adapt to environmental changes on a 24-hour cycle and are essential for metabolic well-being(7–9).Recent studies suggest that energy regulation is linked to the circadian clock, and that the timing and composition of intake may influence obesity. Although the evidence is uncertain, understanding circadian clocks and their relationship to meal timing and composition may be an effective dietary approach to improving the quality of life for people with obesity (5,10).

General Objective: Define the best intake stages for each macronutrient according to circadian rhythms to drive weight loss.

Obesity

Obesity is a chronic disease characterized by an excessive accumulation of fat, which causes low-grade inflammation and can lead to cardiovascular disease, diabetes, musculoskeletal disorders and cancer (7,8). This inflammation, called lipoinflammation, associated with an increase in inflammatory factors and tissue infiltration, which perpetuates obesity and decreases satiety capacity (11). Fat accumulation causes hypertrophy and hyperplasia of adipocytes, leading to insulin resistance and dysfunctional tissue (9,10,12).

In Spain, in 2023, the prevalence of overweight in adults was 55.8% and of obesity 18.7% (4). Obesity is conditioned by multiple factors such as susceptibility in childhood and adolescence, a positive energy balance, genetic and socioeconomic factors, endocrine diseases, hypothalamic alterations, drugs and the chronodisruption of circadian rhythms (1,13,14).

Chrononutrition

The human circadian system generates and synchronizes circadian rhythms with the environment through a network of peripheral oscillators, with its regulatory center in the suprachiasmatic nucleus (SCN) of the hypothalamus (7–9). Light is the main synchronizer of the CNS, transmitting information through retinal ganglion cells and using the hormone melatonin to regulate the biological clock through membrane receptors, especially MTNR1B in the islets of the pancreas and retina (15–20).

In addition to light, other factors such as fasting/eating cycles, activity/rest, and temperature can also influence circadian regulation (8,9,21). At the molecular level, the ´´CLOCK´´ clock genes control the expression of circadian rhythms through transcriptional feedback mechanisms and transductions, forming complexes that inhibit their own synthesis in approximately 24-hour cycles (12,19,22).

The connection between the circadian clock and metabolism is explained by the ability of clock genes to activate transcription factors that influence human metabolism (21,23). This mechanism varies among individuals according to factors such as age and chorotype, which determines sleep and activity patterns and can be influenced by gender, age and diet of the individual (23–25).

Carbohydrate Metabolism

Carbohydrates (CH) are essential biomolecules in human metabolism, mainly as a source of energy, with glucose being the most prominent molecule (26). Vital organs such as the heart, liver, kidneys and brain depend on glucose for their function (27,28). The body can produce glucose by gluconeogenesis in the absence of adequate intake and store it as glycogen in the liver and muscles for use during periods of high energy demand (18,26,27,29,30). Although part of the glucose is stored internally, a fraction remains in the blood, the concentration of which is strictly regulated to avoid hyperglycemia and hypoglycemia (26,31).

Glucose fluctuations, known as glycemic variability, depend on health and dietary factors (32–34). Glucose levels rise and fall within 1-2 hours after insulin administration (33–35). Although glycemic variability can cause harm if peaks are high and persistent, or troughs are slow, it is generally regulated by insulin and glucagon (23,32,34–36).

Glucagon promotes the release of glucose from the liver during fasting, while insulin facilitates the entry of glucose into cells after ingestion (37,38). In type 2 diabetes (DM2), insulin is not used efficiently, causing blood glucose accumulation and conversion to fat, especially in the abdomen and hips, contributing to obesity. Obesity in turn causes insulin resistance and can lead to DM2 if not corrected (36,39–41).

Glycemic variability varies throughout the day due to factors such as the timing and composition of meals, as well as melatonin levels (19,33,42). Melatonin, which increases at night, suppresses insulin release, decreases insulin sensitivity and is related to weight gain and hunger and satiety patterns (33,34,43,44). A study by Martorina et al. (33) found no significant difference in glycemic variability between people with DM2 supplemented with melatonin and those who produced melatonin endogenously, although there was a decrease in significance between the groups according to their chronotype (33).

The action of melatonin receptor (MTNR1B) (43) and the rs1080963 polymorphism, especially the G allele, are related to fasting glucose levels and melatonin expression in pancreatic islets (20,42–44). This allele is also associated with measures of adiposity and weight loss, Goni et al. (44). Studies suggest that high concentrations of melatonin negatively affect glucose tolerance. Garaulet et al. (43) found that carriers of the G allele were at increased risk of developing DM2, which may help to better understand the effects of melatonin on glucose metabolism, sleep disturbances, and breakfast glycemic response (33,34,43,44).

Lipid Metabolism

Fats are essential components in the human body, essential for the storage of energy, the synthesis of vitamins, hormones, bile salts and cell membranes, and the regulation of cell signaling (45–47). There are two metabolic processes for handling fats: lipid anabolism (lipogenesis) and lipid catabolism (lipolysis) (47). Lipogenesis, which occurs mainly in the liver and adipose tissue, involves the formation of complex lipids to store energy and form cell membranes (48–50). Lipolysis, enhanced during fasting or exercise, breaks down lipids to produce energy and metabolites (49–52). Specific enzymes regulate these processes to maintain energy balance. However, diseases affecting these enzymes can disrupt fat storage and cause cellular and tissue damage, especially in the brain, liver and bone marrow (49,52).

Fatty acids, the building blocks of lipids, are stored in adipocytes to form adipose tissue (AT), (5,11,53), which is classified into white (WAT), brown (BAT) and beige (BW) adipose tissue (54–59). The BAT, characterized by mitochondria with cytochromes, regulates body temperature and is found mainly in the central region of

the body, developing in the neonatal stage and transforming into WAT with time (56–61). The WAT is unilocular, composed of a large lipid droplet and some mitochondria, and is subdivided into subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT) (55,57,59,62). TAS is located under the skin, mainly in the trunk and middle area in men and in the hips and buttocks in women (62). HAT surrounds the internal organs in the abdominal cavity and is associated with serious health problems such as insulin resistance and cardiovascular disease (18,57,62).

Melatonin plays a key role in adipocyte regulation, influencing lipolysis and lipogenesis (48,51,63,64). Activates brown adipose tissue, participates in browning of white adipose tissue and regulates energy expenditure and intake (57,58,64). Initial research on hormones in adipose tissue revealed their importance in appetite and energy balance (65). De Luis et al. (66) observed that a high-fat diet affects the expression of endogenous rhythms such as leptin. Studying the expression of clock genes in human adipose tissue has helped to understand their influence on obesity (64,65). In addition, the variation of lipid profiles in individuals with DM2 (67,68) and the impact of breakfast on glycemic control were investigated. The studies by Oliveira et al. (67) and Chang et al. (68) suggest that breakfast composition influences energy balance, associated with the MTRN1B gene (20,66). Polymorphisms in this gene, such as the GC genotype, affect blood lipid concentrations, especially cholesterol, indicating that these polymorphisms may influence the metabolic response to diet and the regulation of adipose tissue (66,69).

Protein Metabolism

Proteins, made up of amino acids, have essential functions in the body, such as the formation of structures and the regulation of organs and tissues (70–72). Protein metabolism includes transamination (73), a process in the liver where an amino group is transferred from an amino acid to an alpha-keto acid, facilitated by transaminases and aminotransferases (72–74). This process aids in the elimination of the amino group, the creation of new amino acids and alpha-keto acids, and their elimination in the urea cycle (72,73,75). Although rarely used for energy, it can occur in cases of high protein intake or prolonged starvation. Normally, amino acids are used in biosynthetic pathways, but an excess can lead to lipid synthesis (72,76).

Protein, stored mainly in skeletal muscle, is essential for protein replenishment, (77) is essential for protein replenishment (76) and plays a crucial role in mobility, metabolic homeostasis and thermogenesis (78). In addition, skeletal muscle secretes myokines that regulate metabolic and lipid functions (79–82). Disorders in protein synthesis and degradation can cause muscle atrophy and sarcopenia, associated with weakness, fatigue and decreased quality of life (78). Sarcopenia, associated with aging, chronic diseases such as cancer and obesity, is associated with falls, fractures and mortality (82–86). Sarcopenic obesity, linked to an increased risk of type 2 diabetes, results from fat accumulation in muscle, which disrupts insulin signaling, impairs insulin sensitivity, and promotes weight gain (80–87).

Sarcopenic obesity and circadian rhythms are closely related and have a significant impact on metabolic and muscle health (80–82). Dysregulation of circadian rhythms, often due to modern lifestyles, may contribute to the development of sarcopenic obesity by affecting the secretion of key hormones such as melatonin, cortisol and growth hormone (66,88,89). Melatonin, in addition to regulating sleep-wake cycles, has antioxidant and anti-inflammatory effects that protect muscle mass. The melatonin receptor MTNR1B is involved in the regulation of glucose and body weight. Studies such as De Luis et al. (90) suggest that a high protein intake, especially

at breakfast, may improve the synchronization of circadian rhythms and have beneficial effects on body composition and metabolic health (90,91). According to Douglas et al. (89) skipping breakfast or consuming foods of low nutritional value can negatively affect appetite control and increase caloric intake, which can impact nighttime glycemic response and overall metabolic health (24,92,93).

Method

Pubmed

The following filters were established: 5 years old and ´´ free full text´´. The following keywords were used:

(Carbohydrates [MeSH Terms] AND morning intake [MeSH Terms]: We found 3 randomized controlled articles, all 3 were used.

(Carbohydrates [MeSH Terms] AND circadian rhythms [MeSH Terms]: Five articles were found, 3 were read for the TFG, 2 were literature reviews that were excluded.

(Lipids [MeSH Terms] AND circadian rhytms [MeSH Terms]: A total of 6 articles were found, of which only 1 was used, since 5 met the inclusion criteria.

(Lipid [MeSH Terms] AND thermogenesis [MeSH Tems]: Giving 2 results and using only 1, since the other was a literature review.

(Lipid [MeSH Terms] AND evening [MeSH Terms]: It yielded 5 results, of which only 2 were used, the other 3 being literature reviews.

(Protein [MeSH Terms] AND obesity [MeSH Terms]: Three results were found, of which all three were used.

(Protein intake [MeSH Terms] AND muscle [MeSH Terms]: We found 2 outcomes and used the 2 randomized controlled trials.

Google Scholar

This search engine proved to be very useful to access full texts, articles or official websites, where the filter was applied to articles between 2019 and 2024.

Macronutrients distribution and obesity: 17300 results, using a total of 7 because of their relevance and because they met the inclusion criteria.

Morning carbohydrates: 1800 results, using a total of 5 that met the inclusion criteria.

Glycolysis and circadian rhythms: 12200 results, using a total of 4 relevant and meeting the inclusion criteria.

Protein intake and weight loss: 10200 results, with only 1 relevant patient meeting the inclusion criteria.

Results

For the reasons given above, chrononutrition may be of interest as a treatment for overweight and obese individuals. The studies that deal with this association are shown in **Table 1.**

Table 1. Table on the association between macronutrients, circadian rhythms and weight loss. Own elaboration.

Reference	Type of study, sample size and characteristics Target	Study groups	Results
Garaulet et al(43)	Randomized controlled trial 845 participants	Conditions: -EE (early dinner) -LE (late dinner)	Higher average melatonin values in LE compared to EE. 3.5 times more. No significant differences between age, sex, adiposity, bedtime and dinnertime. Glucose concentrations were highest in GG, followed by GC and CC. Melatonin levels modulated insulin secretion in all genotype groups. If insulin concentrations decreased, only CG decreased insulin secretion under LE conditions.
Oliveira et al (67)	Randomized controlled trial 82 subjects with DM2 ≥1 year	G1: 41 with a low CH and high fat diet G2: 41 with a diet low in fat and rich in CH	Changes from initial calorie intake Body weight and BMI changes Glycemic changes between the first and last 14 days of intervention.
Sinturiel et al (69)	Cohort study 6 participants Men with and without obesity.	DN: thin DM: Diabetes and obesity	Significant differences in lipid profiles between lean men and men with DM2. Greater variation, especially at wake-up time (6:30-8:00)

			Differences between men and women with DM2. Alteration of SAT lipids in DM2 associated with changes in gene expression related to lipid metabolism and significant variation throughout the day.
Dalgaard et al (93)	Randomized controlled trial 30 young women	Two breakfasts - High in protein (PRO) - High in CH (CHO) -Control day (CON)	There are no differences in the amount of food ingested after test breakfasts. Similar glucose marker levels on all experimental days. After consumption of breakfast CHO and PRO, glucose and insulin levels increased more than after CHO. Lower glucose in PRO than with CHO. No difference between insulin levels between PRO and CHO.
Cunha et al (92)	Randomized controlled trial 14-night workers	HP-MCHO diet (high protein) LP-HCHO diet (low protein)	No significant differences in nutritional characteristics were shown between the two study protocols. The HP-MCHO condition observed lower post-meal glucose values. Both HP-MCHO and LP-HCHO breakfasts elicited similar metabolic responses in terms of glucose, insulin, triglycerides and HOMA-IR.

First, four studies on carbohydrates and circadian rhythm were reviewed (33,34,43,44), three of which were clinical trials suggesting an association between glycemic response variability and interaction with melatonin, especially at night (33,43,44), especially at night. However, (34) the effects in relation to melatonin secretion were not directly examined, but the consequences of the intake of different macronutrients on rest was studied. (33), in a randomized clinical trial, found no significant difference in the glycemic variability of individuals with DM2 and melatonin, which could be due to the lack of specific meals in their study. On the other hand, (43) showed a correlation between late dinners and glucose tolerance, similar results to those of (34) who showed that glucose consumption before bedtime increased insulin sensitivity and worsened sleep (34,43). In addition, no significant relationship was found between genotype, BMI, and sex with glycemic response, although significant variations by ethnicity were observed in the studies of (34) and (44). Secondly, fat metabolism and

chrononutrition were addressed, where (68) and (67) contradictory results were obtained on the effects of melatonin on adipose tissue (67,68), suggested that a low-carbohydrate diet at breakfast had a significant impact with respect to an isocaloric diet, while (67) found a non-significant glycemic variability between the diets (67,68). The differences may be due to the design of the studies, the sample and the duration: the study of (68) lasted three months and was conducted in Canada, whereas the study of (67) lasted only one day and included participants from Canada and Australia. (de Luis et al., 2020) also observed variations in blood lipid concentrations, especially in individuals with the CC genotype of the MTNR1B polymorphism, with significant changes in the morning, coinciding with the findings of (69). Third, results on protein metabolism and circadian rhythms were discussed. Studies such as that of (93) and (89) showed that there were no significant differences in the sensation of hunger and satiety between protein and isocaloric diets, although women who consumed more protein at breakfast had a lower need to eat during the day. Both studies observed non-significant differences in the hormonal response of ghrelin, CCK and GLP-1, as well as a decrease in leptin levels (92,93). Despite these findings, no information was obtained on the effect in men, in DM2 and long term studies, such as the one in (92), possibly due to differences in the study subjects, (24) took into account the chronotype of the individuals, suggesting that nighttime food consumption is associated with higher BMI and higher fat percentage.

Discussion and Conclusions

The results suggest that both the nutritional composition of meals and the timing of meal consumption during the day are effective dietary strategies for weight loss. Although more research is needed to define more precisely the optimal times for the intake of each macronutrient, it can be concluded that consuming macronutrients at specific times of the day can be an effective nutritional strategy to improve body composition and promote weight loss in overweight and obese individuals.

Once the articles have been read, some limitations could be taken into account for the development of future research, the following points are proposed:

To improve the quality and relevance of studies in metabolic health and body composition, it is essential to implement several important changes in research methodology.

First, it is essential to broaden the diversity of the samples to include a more equitable representation of different demographic groups, ages, genders and ethnicities. This diversification will allow a deeper understanding of the effects of biological and sociocultural variables on the results, ensuring that the conclusions are more generalizable and applicable to a broader population.

In addition, it is crucial to incorporate a greater number of long-term studies. These studies are necessary to evaluate the sustained effects over time of interventions on metabolic health and body composition. The collection of data over time will provide valuable information on the efficacy and durability of interventions, allowing the development of more effective strategies for the management and prevention of metabolic problems.

Another important aspect to consider is the inclusion of a greater number of women in the interventions. It is vital to explore the metabolic variations that exist between women and men, such as the influences of menstruation on metabolism.

Understanding these differences will allow the design of more personalized and effective interventions for both genders.

It is also necessary to evaluate the influence of the time of year on the studies. Time changes, such as summer and winter time, can alter the circadian rhythm, especially affecting breakfast and dinner times. Analyzing how these seasonal changes influence outcomes will allow interventions to be adjusted to be more precise and effective, taking into account variations in people's biological rhythms.

Conflict of Interest

I declare that the work submitted for publication in the journal mls health & nutrition research is original and has not been and is not currently under evaluation in any journal or conference. Likewise, I am responsible for the content of the same and I agree that my name appears as the author. Finally, I declare that I have no conflict of interest in those activities that could introduce bias in the results of the work.

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Influence of nutrition on the improvement of sport performance in speed swimming

Influencia de la alimentación en la mejora del rendimiento deportivo en natación de velocidad

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ABSTRACT

The aim of this work is to develop a dietary guide specifically designed for sprint swimmers, to help them select the right nutrition to enhance their performance. Bibliographic review of the scientific literature of the last five years thanks to the use of bibliographic search engines. Consequently, 33 relevant studies were found and analysed for their scientific relevance to the topic. The set of studies indicates that the diets analysed (Mediterranean diet, ketogenic diet, high-carbohydrate diet and intermittent fasting diet) generally improve performance. However, in the case of sprint swimming only the Mediterranean diet and the high carbohydrate diet show favourable data, since the other two show that the improvement in performance occurs at low intensities 65% of VO2max in women and 80% of VO2max in men. Due to the metabolic needs of sprint swimmers, both the Mediterranean diet and the high carbohydrate diet are suitable to improve their performance. However, in the long term the high carbohydrate diet may be detrimental to health compared to a balanced diet.

Palabras clave:
Dieta Mediterránea, nutrición deportiva, dieta para nadadores, metabolismo en nadadores, estrategias nutricionales.

RESUMEN

El objetivo de este trabajo es elaborar una guía alimentaria específicamente diseñada para nadadores de velocidad, para ayudarlos a seleccionar una nutrición adecuada que potencie su rendimiento. Revisión bibliográfica de la literatura científica de los últimos cinco años gracias al empleo de los buscadores bibliográficos. Consecuentemente, se encontraron 33 estudios relevantes, los cuales fueron analizados por su relevancia científica hacia el tema. El conjunto de estudios señala que las dietas analizadas (dieta Mediterránea, dieta Cetogénica, dieta alta en hidratos y dieta de ayuno intermitente) por lo general mejoran el rendimiento. Sin embargo, en el caso de la natación de velocidad solo la dieta Mediterránea y la dieta alta en hidratos muestran unos datos favorables, puesto que las otras dos muestran que la mejora en el rendimiento se da a intensidades bajas 65% del consumo máximo de

	oxígeno (VO2 Máx.) en mujeres y 80% del VO2 Máx. en hombres. Debido a las necesidades metabólicas de los nadadores de velocidad tanto la dieta Mediterránea como la dieta alta en hidratos de carbono son adecuadas para mejorar su rendimiento. No obstante, a largo plazo la dieta alta en hidratos puede ser perjudicial para la salud en comparación con una dieta equilibrada.

Introduction

Nutrition is a key aspect to improve athletes' performance. This is because nutrients are the fuel used by the body both for optimal performance and for recovery after physical exercise (1).

However, nowadays, thanks to the development of new technologies, especially the Internet and social networks, people's eating habits are highly influenced. In particular, children are highly vulnerable to what is transmitted through social networks, especially when it comes to unhealthy habits compared to proper nutrition campaigns, which tend to be less noticed by this segment of the population (2).

Typically, in sports that require high intensity efforts, most athletes tend to opt for a diet rich in carbohydrates to meet their energy needs and increase their performance during the match or event (3). However, in the case of such sports, the intake of a diet rich in carbohydrates can increase the fat in the central area, thus impairing the athlete's performance (4).

In the case of sprint swimming, there has been a tendency to change the characteristics of the diet towards a more balanced diet, not high in carbohydrates (5). In addition, although swimmers do not usually have a high central fat index, due to the high training volume, the Mediterranean diet is recommended as an alternative due to its healthy properties (6).

Throughout this review, an evaluation of the current literature on the different diets most commonly used by athletes will be carried out describing their benefits, diet content, adherence and detrimental effects. Some of the most studied diets are the Mediterranean diet, ketogenic diet (KD), high carbohydrate (HC) and intermittent fasting. The possible adverse effects of the different diets when the swimmer does not follow them properly will also be taken into account.

Method

In order to carry out this Final Degree project, taking into account that it is a literature review, a search for articles was carried out to compare the effect on sports performance and health of the different diets most commonly used today.

This literature search on the subject began on February 8, 2023 and ended on April 29, 2024. The scientific literature was found after searching in different databases, taking into account different inclusion and exclusion criteria.

Continuing along this thread, the inclusion criteria taken into account are as follows: studies that have been published between 2019 and 2024 and that are reviews, meta-analyses, experimental studies, clinical trials, case-control studies, cohort studies or observational studies. Consequently, the exclusion criteria used include studies whose population sample is less than 5 persons, whose age is more than 5 years old and whose language is neither Spanish nor English.

Figure 1 shows the keywords and Boolean markers used in each bibliographic search engine and the results obtained.

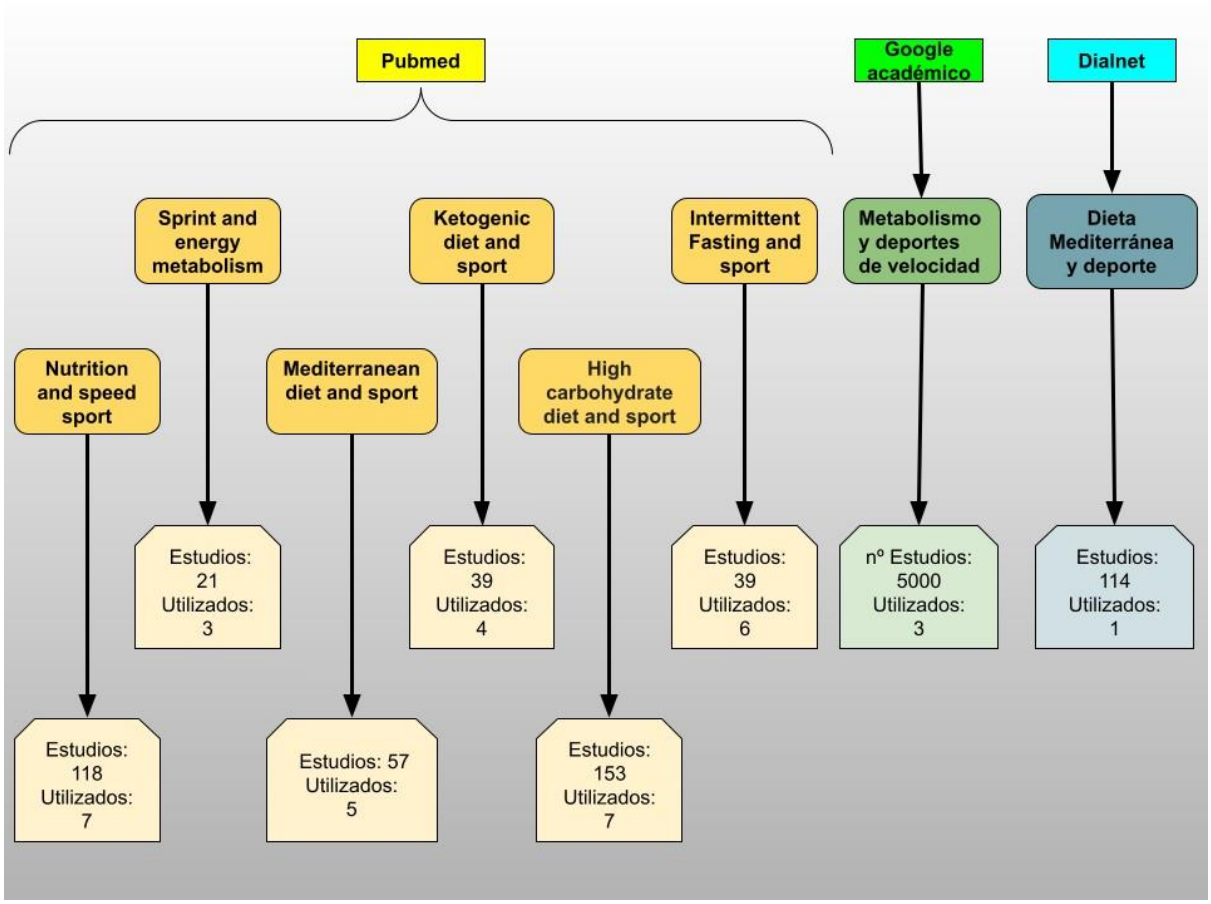

Figure 1. Search methodology used in the article

Results

Speed swimming is that which comprises the distances of 50 and 100 meters. Typical in these competitions are fins with times ranging from 20 seconds to less than one minute, respectively. This distance must be covered by the swimmer in the shortest possible time and at maximum intensity, which means that the anaerobic pathways provide most of the energy compared to the oxidative pathways (7).

As in other sprint sports, the energy pathway that will predominate in the 50 and 100 m races is anaerobic. Therefore, the limiting factor in this sport would be the depletion of ATP-PCr reserves (7). However, other authors relate the appearance of central fatigue, caused by metabolic acidosis, as the main cause of decreased performance (8).

That said, the main energy pathway will vary depending on the distance of the event. Therefore, athletes should work on all energy pathways, prioritizing those shown in Table 1 and ensuring that energy stores are replenished through proper nutrition (9).

Table 1. Relationship between energy systems and swimming speed distances. (7)

Weather (s)	Distance	% ATP-PCr	% Anaerobic glycolysis	aerobic metabolism
10-15	25 m	50	50	0
19-30	50 m	20	60	20
40-60	100 m	10	55	35

Mediterranean Diet

The Mediterranean diet has been used by the countries surrounding the Mediterranean Sea for hundreds of years, and is based on lean protein, such as fish and chicken, fruit and vegetables, berries, nuts and olive oil (10). The great benefit that has been commonly associated with this diet is that it reduces the risk of different diseases, such as cancer, and it is currently being studied for its anti-inflammatory qualities compared to Western diets (11).

Usually, the Kidmed questionnaire is used to assess the adherence to the Mediterranean diet by the child population. This questionnaire takes into account that they eat more than two pieces of fruit a day; they eat at least once a day vegetables, either fresh or cooked; they eat fish 2-3 times a week; they eat at least one serving of legumes a week; they eat pasta or rice 5 times or more a week; they eat some cereal or derivative for breakfast; they eat nuts 2-3 times a week; eating two servings of dairy products a day; using olive oil (12).

If we talk about sports performance, the Mediterranean diet shows that it helps to improve performance on the basis that it performs a body recomposition, reducing the fat index of athletes. It also reduces the inflammatory effect that the body produces in response to high-intensity training (13). This can help swimmers, as a low abdominal fat index is key to improved performance (6).

In addition, in the case of a study conducted on CrossFit athletes, after following a Mediterranean diet for 8 weeks, there was an improvement in the performance of the athletes, since the maximum number of repetitions was improved (13). Another study similar to the previous one in which runners and kickboxers were subjected to a change in their eating habits, redirecting the athletes to a lifestyle in line with the Mediterranean diet. This produced an increase in performance in both groups of athletes, the runners saw their VO2max increase and the kickboxers saw an increase in the squat and counter movement jump (CMJ)(14).

In summary, the Mediterranean diet stands out for its ability to help athletes achieve their goals. This is because, despite providing a moderate caloric intake, it manages to supply individuals with the nutrients necessary to support workouts, while keeping body fat levels low (15,16). This added to the fact that in general it is a diet moderately easy to follow by the population (17) and that it provides foods rich in antioxidants (fruits and vegetables) (11), make this diet a good option for swimmers looking to improve their performance and broaden their nutritional options.

Ketogenic Diet

The impact that this diet has on athletic performance is the fact that several studies show how the subjects after being subjected to a low carbohydrate intake see how the metabolism of carbohydrate oxidation slows down, which means that the glucose reserves can remain high until the end of the test which maximizes the performance of the athletes (18).

An example of a study that supports the above is the one conducted on Cross-fit athletes, 11 men and 11 women, who underwent a DC for four weeks. As a result, it was found that men increased fat utilization, mainly in exercises at an intensity of

80% of VO2max. However, this did not occur in women, who only saw their metabolism vary at intensities lower than 65% of VO2max (19).

Another study conducted the same year on endurance athletes showed that performance was not affected in athletes with DC compared to the control group when exercises were performed at intensities lower than 65% of VO2max. In addition, the time to onset of fatigue did not vary between the two groups of athletes (20).

However, both studies do not clarify what happens when subjects approach submaximal intensities, as is the case in sprint swimming. Therefore, one could take as a reference the study conducted on 25 men practicing endurance sports by subjecting them to a CD and a reintroduction to carbohydrates at week 10. This study shows that there is no change in strength and power between the control group and those subjected to DC when performing squat, bench press and dead weight exercises at intensities greater than 85% or RIR 0 (repetitions in reserve) (21).

Despite all of the above, a study conducted in 2019 in which 16 23-year-old men and women were subjected to 4 days of a DC, indicated that, when performing an anaerobic exercise, in this case stationary cycling and the Yo-Yo test, there was a decrease in the watts and meters achieved in the aforementioned tests. These facts have a very important impact on those athletes whose sport is of high intensity and short duration (22).

Another negative aspect of the CD would be the reduction of muscle mass due to the fact that such a diet may not cover the total nutritional requirements of athletes. This in turn has an impact on bone health as studies have shown how serological markers of bone health are altered by the use of the ketogenic diet for short periods of time. This aspect is of vital importance mainly in endurance sports and in those in which the athlete's triad may appear on a regular basis (23).

To finish with this diet, mention the difficulty that the population usually finds in following such a restrictive diet compared to others such as the Mediterranean diet (24).

High Carbohydrate Diet

The HC diet is characterized by the fact that more than 55% of the total calories obtained from food come from carbohydrates. In addition, due to the wide variety of carbohydrate-rich foods available for consumption, it can be stated that the main function of these foods in the human body is to be used as fuel. This is because this macronutrient can be metabolized quickly to generate energy for high-intensity exercise (25).

In the case of most sports, especially those of long duration, the so-called crossover point occurs. This point can be defined as the physiological state of an athlete in which the energy demands go from being satisfied mainly by fat metabolism to glucose metabolism being essential to continue performing an activity (26).

That said, at first glance it appears that this diet, by providing muscle fuel, is a good choice for improving athletic performance. However, one study showed that

endurance athletes who maintained a high carbohydrate diet (10 g/kg/day) compared to the 6.5 g/kg/day control group for 14 days had no significant difference in increasing running speed. In addition, although both groups saw their fat mass decrease, the athletes who were subjected to the diet suffered less fat loss (26).

On the other hand, another study comparing an HC diet or a DC diet for a short period of time (three weeks) in 24 adults showed that the HC diet had a greater effect on the performance of the athletes, i.e., these subjects achieved a higher VO2max, longer time to onset of fatigue and a better watts/kg ratio. Also, both diets obtained similar data in terms of weight loss (25).

The two previous studies refer to athletes whose sport was endurance. In contrast, this article again compares two groups of amateur athletes, one subjected to a low-carbohydrate diet and the other to a high-carbohydrate diet but this time on submaximal efforts performed on a stationary bike. As a result, it was found that the group that improved its performance to a greater extent throughout the tests was the group that was subjected to the HC diet (27).

Continuing with this type of studies in which the sample performs a sport in which the anaerobic pathway predominates. It was intended to demonstrate that eating a carbohydrate-rich, caffeinated meal prior to intervallic training can improve results. Consequently, it was found that there were no alterations in performance due to either the carbohydrate-rich meal or the caffeine (28).

As for swimming itself, a study was conducted in which swimmers were subjected to a HC diet (69% carbohydrate, 16% fat and 16% protein) and another group of swimmers were subjected to a low-carbohydrate diet (16% carbohydrate, 67% fat and 18% protein). After those three days the swimmers had to swim at intensities of 50, 60 and 70 % of the maximum aerobic capacity. As a result, it was shown that a high-carbohydrate diet did not affect glucose utilization at medium intensities (29).

One of the negative aspects of carbohydrates is that, depending on the time they take to be assimilated, they can have adverse effects on the gastrointestinal system (30). This is because ingesting large amounts of carbohydrates can cause the bacterial communities present in the intestine to suffer great stress as a consequence of their work in digesting the enormous amount of nutrients. This can cause athletes who are not accustomed to these abundant intakes of carbohydrates to suffer from indigestion or constipation, thus decreasing their performance (31).

Finally, for this diet the literature does not show any studies that discuss its adherence in sport. Consequently, a study conducted on obese adults showed that a priori a diet rich in carbohydrates is more palatable and therefore more appetizing. However, it can also decrease satiety and increase heartburn, making it difficult to adhere to this type of diet (32).

Intermittent Fasting Diet

Intermittent fasting is a practice that consists of restricting food for a few hours during the day or even for a whole day. This type of diet has gained prominence among athletes because it is used by "*influencers*" and by some professional athletes (33). The expected effect of this diet is that, after 3-8 hours of

fasting, gluconeogenesis is activated in order to maintain blood glucose levels, which increases fat oxidation to create ATP in the muscles (1,33).

Having said that, it is clear that this type of diet is commonly used for weight loss, however, a study of active women showed how this diet and high-intensity interval training can help improve both body composition and athletic performance (34). This is supported by the study conducted on 40 men performing Ramadan and practicing an endurance sport, who saw an increase in their performance and had no problems with muscle catabolism. However, it was found that men who were fed had better results than those who were not fed (35).

However, in professional athletes, results similar to those described above were obtained, as shown in the study carried out on endurance runners, in which it was seen that the effects of training were not diminished. Also, body composition had similar values following intermittent fasting as the control group (36).

A year later, another analysis conducted on elite cyclists showed similar results to the previous study, with both performance and body composition improved compared to the control group. What follows is that intermittent fasting may be a strategy to consider in sports that rely on body composition and are endurance sports (37).

However, all the articles mentioned above only refer to sports with a highly aerobic component, which is far from the objective of this study. Thus, an analysis conducted on thirteen adolescent handball players aimed to show the effects of caffeine on performance in maximal tests (the SJ test, the Illinois agility test and 5 m *shuttles* test) during the month of Ramadan. It showed that caffeine increased performance, but these tests revealed that during the month of Ramadan the adolescent girls suffered a decrease in performance compared to the same tests performed one week before the start of the diet (38).

In summary and in accordance with the above, intermittent fasting is a strategy that does not negatively affect the aerobic performance, strength and fatigue rate of athletes. However, this type of diet may show a deterioration of the sprinting and Wingate capacity, i.e. the anaerobic capacity of athletes (39).

Discussion and Conclusions

The articles found on the Mediterranean diet explore its effects on sports performance in different sports modalities, such as CrossFit training, endurance exercise, ski racing, kickboxing and swimming, in both an adult and an adolescent population.

The study by Ficarra S, et al. (13) examines the effects of the Mediterranean diet combined with CrossFit training in trained adults. Finding significant improvements in performance and body composition, suggesting that this combination may be beneficial for active individuals.

On the other hand, Soldati et al. (14) and Baker et al. (15) research on the effects of the Mediterranean diet on sports performance. Both studies found improvements in the aerobic capacity of the subjects. However, the first shows how the Mediterranean diet does have positive effects on anaerobic power and the second concludes that anaerobic improvements are negligible. However, it is true that this last study stresses the importance of doing research that lasts longer in order to verify whether the Mediterranean diet is efficient in improving anaerobic exercise performance.

The study by Helvaci et al. (16) focuses specifically on adolescent athletes and finds improvements in performance and lactate clearance with a Mediterranean-style diet after 20-meter sets. This suggests that this type of ditta may be especially beneficial for a youth population when the exercise they perform requires maximal or submaximal efforts.

Finally, Altavilla et al. (6) and Calella et al. (17) analyze adherence to the Mediterranean diet among adolescent and university athletes. It is found that there is good adherence to the Mediterranean diet among these athletes, indicating that it is a viable and popular option among athletes.

Taken together, these studies suggest that the Mediterranean diet may have significant benefits on sports performance and body composition in both adult and adolescent athletes. However, more research is needed to find the best way to implement this diet in different sporting contexts, as it is often a hypocaloric diet which may produce some risk for athletes (15,16).

Selected articles on the ketogenic diet indicate how it affects different aspects of sports performance and health in different populations, from CrossFit athletes to runners and endurance trainers.

Effect on sports performance: while Durkalec-Michalski et al. (19) and Shaw et al. (20) observe certain negative effects on performance, especially in high-intensity and submaximal exercise, Wilson et al. (21) find no significant impact of the ketogenic diet compared to the Western diet on strength and power in a group of men at high intensities. On the other hand, Wroble et al. (22) reported a decrease in anaerobic performance in both women and men, more specifically, at intensities greater than 65% of VO2 max in women and 80% of VO2 max in men.

Effect on body composition: Wilson et al. (21) points out that the ketogenic diet does not adversely affect body composition which, as mentioned above, is key to improved swimming performance.

Bone health: Heikura et al. (23) find that a short-term ketogenic diet can negatively affect bone health markers. Which highlights the importance of considering the long-term effects of this type of diet on the athlete's bone health.

Adherence to the diet: Landry et al. (24) found that the Mediterranean diet and the ketogenic diet have similar adherence in the population. However, the results show a slightly better level of adherence to the Mediterranean diet.

Overall, these studies highlight the complexity of the effects of the ketogenic diet on sports performance and health, and the importance of considering factors such as type of exercise, duration of diet, and adherence to the diet to fully understand its impacts.

The studies sought about the HC diet show the impact it has on the physical performance and body composition of athletes of different sports modalities.

The study by Wachsmuth et al. (25) compared a high-carbohydrate/low-fat diet with a low-carbohydrate diet in physically active adults. They found that the high-carbohydrate diet improved the performance of individuals. However, it was observed that blood triglycerides increased markedly, which in the long run can harm individuals and their performance.

Baart et al. (27) examined the effect of a low-carbohydrate, high-fat diet on exercise efficiency and economy in male amateur athletes compared to a high-carbohydrate diet. They found that the latter diet showed better results than the low-carbohydrate diet, despite the fact that the latter is associated with improved fat metabolism. This suggests the importance of carbohydrates in this sport.

This is in agreement with the study by Bestard et al. (29)in which the effect of low and high carbohydrate diets on swimming economy was compared. They found that low-carbohydrate diets did not improve swimming economy, suggesting that carbohydrate needs may be important for this type of exercise and more so at high intensities.

King et al. (26) investigated the effects of a high-carbohydrate diet and "gut training" in elite endurance athletes. They found that these interventions had minimal effects on gastrointestinal status and performance, suggesting that they may not be effective strategies for improving performance in highly trained athletes.

Hulton et al. (28) investigated the effect of the addition of caffeine and a carbohydrate-rich diet before intermittent exercise. They found that neither caffeine nor carbohydrate feeding improved performance. The authors themselves point out that the small sample size could have negatively affected the result.

Finally, the study by Furber et al. (31) found an association between gut microbial stability and improved endurance performance in athletes following dietary periodization, suggesting that gut health may play a role in athletic performance. In addition, it found that the high-carbohydrate diet can be detrimental to the gut microbiota of athletes.

Taken together, these studies highlight the complexity of the relationship between high-carbohydrate diet and physical performance, and underscore the importance of considering the individual needs of athletes when designing dietary strategies to improve performance and health.

The articles reviewed examine the impact of intermittent fasting (IF) and temporary food restriction (TRF) on body composition and physical performance in various populations and sporting contexts.

The study by Martínez-Rodríguez et al. (34) examines how HIIT and intermittent fasting affect body composition and physical performance in active women. While in the article by Triki et al. (35) investigate the timing of resistance training during Ramadan fasting and its effect on muscle strength and hypertrophy. Both studies show two quite different types of population but show quite similar results in terms of improved sports performance and improved health. The first showed how this nutritional strategy is valid to improve body composition and performance at the same time and the second showed an improvement in performance without a decrease in muscle mass. Despite this, the second study shows how the control group presents better results in terms of performance.

With respect to another population group, such as elite athletes. Tinsley G.M., et al. (36) and Moro T., et al. (37) found that intermittent fasting can be a strategy to be considered by athletes whose sports are endurance sports. Since in both studies it is found that the performance of the athletes was improving without any repercussion on the health of the athlete. Furthermore, in these sports, weight is a key indicator for performance improvement and both studies were successful in ensuring that subjects maintained adequate body composition.

On the other hand, the study by Bougrine H., et al (38) whose main objective was to demonstrate the increase in sports performance during Ramadan thanks to caffeine supplementation. The result was that, despite the improved results due to the use of caffeine, the athletes showed poorer submaximal and maximal effort results compared to the week before they started intermittent fasting due to Ramadan.

In summary, the articles show clear evidence that intermittent fasting may be an appropriate strategy for endurance sports. However, in sports with an anaerobic component or intermittent efforts.

Limitations

After reviewing recent articles on the relationship of different types of diets with the improvement of performance in the sport of swimming, more specifically in the speed modalities. To point out a set of aspects to be taken into account when carrying out new studies on this subject:

The first aspect to mention is the scarcity of studies found that directly relate swimming to a specific type of diet.

The second aspect to be improved is the methodology of the studies themselves, since most of the studies found present a fairly small sample and tend to compare diets with each other, without a control group or without taking it into account.

The third and last aspect to take into account is the duration of the studies. It would be appropriate to conduct a study covering a full season in order to compare how the different diets adapt to the different seasonal loads.

Having performed the analysis of the current literature, it should be noted that there is still a long way to go to find the most suitable diet for sprint swimmers. Since this population group is very heterogeneous and each individual may present very different variables to be taken into account. However, the literature shows how there are different diets that may have a greater effect on performance than others.

Regarding the Mediterranean diet, it is important to highlight its great variability of contexts in which it can be carried out. There is enough evidence to affirm that this diet can be a relevant factor to improve performance in both aerobic and anaerobic sports. In addition, its characteristics make it a very complete and balanced diet. However, this diet is often low in calories, which can negatively affect swimmers.

As for the ketogenic diet, despite being a dietary pattern that shows results in improving the body composition of the subjects, which is related to improved performance. It is not the best choice for sprint swimmers as studies show that performance at maximum intensities is impaired by this type of diet. In addition, although swimming is a low-impact sport, there are studies that link this diet to bone health problems, which can be harmful to elite swimmers because of their strength and plyometric work.

Continuing with the high-carbohydrate diet, evidence suggests that swimmers may consider the high-carbohydrate diet to improve performance in their sport. In spite of the above, the evidence found compares this diet with the low-carbohydrate diet, so more studies would be needed to be able to fully affirm the above. Also note that this diet can alter both blood triglyceride levels and gut microbiota. These aspects can be detrimental to the health of athletes.

Finally, the intermittent fasting diet shows significant evidence in improving performance in endurance sports and in the health of athletes. However, when it comes to improving results in sports dependent on the anaerobic system, such as sprint swimming, studies show a clear worsening of results.

To summarize, it is clear that both the Mediterranean diet and the HC diet are good options for swimmers. Nevertheless, it would be more advisable to follow a Mediterranean diet as it has fewer associated long-term health problems than the HC diet. However, the Mediterranean diet, in order to maximize performance, must be adjusted to the individual needs of the swimmer. Therefore, the nutritionist should work together

with the trainer to make the appropriate adjustments to this type of diet according to the training loads and the time of the season.

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