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To Estimate The Carbon Footprint Of Diet Of 15-30-Year-Old Athletes Involved In Different Sporting Activities

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Abstract:

This study examines the carbon footprint of the diets of athletes aged 15 to 30 who participate in various sports. To examine the total carbon emission, the study calculated the carbon footprints of the various food groups and their sub-food groups, including cereals, meat, dairy products, vegetables, fruits, confectioneries, sugar, fats, and oils. Athletes in India have high carbon emissions associated with cereals and dairy products because of their high-energy dietary needs. Cereals and dairy products are often the staple food in the Indian diet and are used as an important source of energy for athletes. These food sources are highly processed and require large amounts of energy and resources to produce, thus leading to high carbon emissions.

Chapter 1: Introduction:

1.1 Changes in the Climate and the food system

One of humanity's most urgent challenges is addressing climate change. The primary source of greenhouse gas (GHG) emissions in the energy and transportation sectors is the burning of fossil fuels. However, it has been determined that the food industry is yet another important factor in human climate change. About 30% of all GHG emissions in Europe are attributable to food consumption (EC, 2006).

The greatest pressing environmental issue of our time is undoubtedly global climate change. 17 of the 18 warmest years on record, according to global yearly temperature records going back to 1880, have taken place in the 21st century. In addition, more than 25 communities along the Atlantic and Gulf Coast are experiencing an increase in the frequency of daily tidal flooding as a result of sea level rise. There is no doubt that climate change hurts people's health worldwide. The improvements in public health made over the past 50 years are at risk of being undone by human-induced climate change. (Donald Rose, March 2019)

Compared to the GHG emissions from energy use, transportation, and post-farm food production, carbon dioxide (CO2) from fossil fuel combustion is not the main component of direct agricultural emissions, but rather methane (CH4). emissions of nitrous oxide (NOx) and methane (CH4) (N2O). These emissions result from biological processes that are naturally occurring and are sped up by human actions like fertilization and maintaining a lot of ruminants. Food production also contributes to indirect GHG emissions from land use change due to its demand for agricultural land (LUC). Large amounts of carbon that are locked in soils and biomass are released into the atmosphere as CO2 as land is cleared for farming (UCS, 2011; Houghton, 2012; CCAFS, 2013).

1.2. How to cope with environmental and health challenges:

Changing existing eating habits to nutrient-dense, sustainable diets is one way to solve environmental and health challenges. A straightforward macro-level intervention would be for governments to advocate for diets that are both nourishing and sustainable and to incorporate these recommendations into nutrition and food-related policies, even though dietary shifts may necessitate interventions on multiple levels, including macro-level policy changes and micro-level behavior change. There is still work to be done on integrating environmental sustainability, such as dietary impacts on GHGE, into countries' FBDG, even though many countries have already developed FBDG to promote a culturally relevant, nutritious diet and to address nutrition-related public health concerns. (Kovacs, B., Miller 2021)

As the world population rises, approaching an anticipated 9.8 billion people by 2050, and as climate change affects the world's food supply and global food security, sustainability in FBDG will become increasingly important. Over the past few decades, several changes in the climate system have been noted, including rising temperatures, warming oceans, rising sea levels, and melting ice sheets. Increased levels of anthropogenic greenhouse gas emissions (GHGE), which are still rising, are linked to many of these changes. Approximately 14.5% of the total global anthropogenic GHGS is attributed to livestock, making agriculture one of the main contributors to GHGS within food systems. Food systems are projected to contribute up to 29% of the entire global anthropogenic GHGE (Albert JL, 2007).

1.2.a. Individual's health to be partially reliant on planetary health:

Making minimal-impact lifestyle decisions allows an individual's health to be partially reliant on planetary health and vice versa. Diets that are unhealthy and unsustainable for the environment are frequently processed, rich in calories, and lacking in nutrients, for example, saturated fat. A sustainable diet consists primarily of fruits, vegetables, whole grains, legumes, nuts, and unsaturated oils, with small amounts of seafood and chicken. This suggests that diets should include little red meat, processed meat, added sugar, and refined cereals. Increased adoption of this diet could reduce GHG emissions by 45% while preventing a fifth of adult deaths that occur prematurely. Based on several measures, it has also been demonstrated that more sustainable diets have higher diet quality scores. (Shukla PR, 2019)

One of the biggest causes of climate change is food production. The sorts of foods produced, which are affected by customer demand, have a significant impact. According to the most recent UN FAO figures, the production of simple meat and dairy is responsible for 14.5% of all global greenhouse gas emissions calculated that by altering current diets, GHGE from food might be decreased by up to 50% based on a systematic review.

Even for the same food product, the CF varies greatly depending on the manufacturing system and methodological decisions used during the CF measurement. The pattern that has formed, nevertheless, is that cattle goods typically have a much higher CF than plant-based foods (EC, 2006), while several plant-based foods with high CF values have been developed for production in heated greenhouses, air transportation, or low-yielding systems. Due to the extraordinary levels of CF in beef and lamb, followed by cheese, in ruminants, enteric fermentation in ruminants contributes CH4 (Stoessel et al., 2012).

India has the highest population of vegetarians in the world, and a high percentage of the nonvegetarian population are "flexitarians" or "casual vegetarians," that is, those who consume animal-based foods occasionally. There is high consumer perception and demand for plant-based foods. Consumer demand for plant-based alternatives, including nut-based milk, soy products, pulses, and plant-based protein supplements, for meat and other animal-based food products has grown along with growing environmental consciousness, in part because of a perception that plant foods have a lower environmental effect. Due to this market trend, the key issue that arises is the quantity and quality of dietary protein. This may partly explain the concurrent existence of protein inadequacy in the majority of the population. Animal products, including eggs, lean meat, and low-fat dairy are rich in high-quality protein. However, the primary issue that emerges is that animal foods have a higher carbon footprint. Consequently, there arises a need to tackle the ambiguity of whether animal-based foods or plant-based foods provide optimal nutrition and sustainability to establish nutrition security.

1.3 How Can You Lower Your Food's Carbon Footprint?

1.3.a. Consume less meat:

It takes a lot of land and other resources to produce final meat products, making meat a resource-intensive food source. As previously mentioned, livestock causes a lot of methane production and catalyzes deforestation, which results in emissions and the loss of an important carbon sink.

By consuming high-protein plant-based foods instead of meat, like beans, tofu, or Quorn, you may lessen your carbon footprint while also attempting to lower the world's demand for meat and the effect that food has on the climate.

This does not require you to eliminate meat and other animal products from your diet. In reality, healthy livestock raised in a biodiverse food system can operate as a beneficial tool for nutrient cycling and can provide delicious, nutrient-dense meals. Saving meat for special occasions and only purchasing organic beef, on the other hand, can significantly lower your contribution to carbon emissions. This is why it's crucial to create a more mindful relationship with meat (Brooks et al. (2011).

1.3.b. Choose organic food:

Organic food can be obtained in a variety of ways and is grown using a variety of farming techniques. If you buy organic food, however, you can usually be sure that it was grown using fewer or no chemicals than those that are routinely used for fertilization, pest control, and preservation. Consuming fewer chemicals is better for your health, but doing so also means that you are less likely to encourage the usage and manufacturing of chemicals in industry, which are items with a large carbon footprint (Smith et al., 2005).

1.3.c. Buying locally:

In addition to cutting your emissions by limiting the distance your food must travel, there are other benefits to purchasing locally. If you can purchase food directly from local small-scale farmers or farmers in your neighborhood, likely, their products are not included in large-scale food supply chains. Thus, the possibility that industrial methods and equipment were employed to produce their food is reduced. In any case, there will probably be more information regarding the food's production, enabling you to make wiser dietary decisions. Another great approach to keep money flowing in your neighborhood economy is to buy locally (Cederberg et al., 2009b).

1.3.d. Make more home-cooked meals:

Cooking at home enables you to take more ownership of the materials that go into the food you consume, empowering you to make more responsible and knowledgeable choices regarding your food's carbon footprint. By cooking enough food for several meals at once or conserving and eating leftovers, you can reduce food waste and the carbon emissions that come from cooking with careful planning. By using food that you have grown yourself and turning food waste into carbon-absorbing compost and soil rather than letting it rot in a landfill if you have a garden, you can lessen this impact even further (Brooks et al. (2011).

1.3.e. Reducing, using, and recycling:

The adage "reduce, reuse, recycle" can help us come up with ideas for reducing our carbon footprints. You can lessen the amount of food that spoils right away by exercising extra caution when you buy food. If everyone did this, we could all reduce our consumption of food and the impact of our carbon-intensive food systems. Buying less and only what you need will lower waste emissions from landfills. By purchasing products in bulk from local suppliers and choosing products with the least amount of packing necessary, we can also reduce the amount of packaging we create and discard (Gustavsson et al., 2011).

Generally, there are separate techniques in place to evaluate data about each protein and its sustainability. These include life cycle assessment (LCA), a common approach for assessing the environmental impact of the food, and the digestible indispensable amino acid score (DIAAS), a comprehensive evaluation that reflects the true ileal digestibility of the indispensable amino acids that are present in food items and provides a number related to the protein quality of the food. However, the LCA data available does not take into account the protein content of the food, and the LCA comparisons done based on the protein content of the food in past studies failed to distinguish between the actual bioavailability of the protein. Protein quantity and quality differences across foods influence inferences on sustainable diets and nutrition security.

1.4 Impact of a carbon footprint on the environment:

The database of Food Impacts on the Environment for Linking to Diets (dataFIELD), which is based on an exhaustive evaluation of the life cycle assessment literature, contains information on the greenhouse gas emissions (GHGE) for the manufacturing of various foods. This review comprised public domain English-language articles and studies that were published between 2005 and 2016. For the great majority of the 332 commodities in this database, cradle-to-farm gate impact factors were used. There is insufficient research to determine the GHGE values of foods at the country level, even though different production methods have an impact on GHGE values. DataFIELD comprises studies from throughout the world (Painter J, Rah J-H, Lee Y-K2002).

Therefore, we used the same mean GHGE values for 58 FAO commodities and four OECD-FAO dairy products for all nations considered here, expressed as carbon dioxide equivalents per kilogram of food (CO2-eq/kg). For some commodities that contained a variety of items (such as "nuts and goods" and "freshwater fish"), aggregate values were created. Five other commodities were not included in our research because GHGE data were not available for them. Cephalopods, aquatic creatures other than fish or seafood, sorghum, palm kernel oil, and rice bran oil were the only products that made up less than 10 kcal per person per day in average consumption patterns (Altamirano Martinez MB, 2005).

1.5 How do nutrition quality indicators evaluate health or nutrition sustainability?

Typically, nutritional quality indicators and/or health outcomes are used to evaluate the health nutrition dimension or nutritional sustainability. In this regard, some research has used food-based, nutrient-based, or predictive public health models to model more environmentally friendly diets. In other instances, the effects of adopting dietary patterns like the Mediterranean diet (MD)on health and the environment have been investigated. Numerous studies have shown that healthier diets generally have less of an impact on the environment; as a result, higher-quality diets have been linked to reduced GHGE (Trolle, E, 2022).

Other researchers, however, did not come to the same conclusions, demonstrating that sustainability dimensions such as the GHGE and the health nutrition dimension of diet were not always compatible with one another, possibly due to the known negative correlation between dietary energy density and nutrition. Despite having a higher percentage of low-GHGE foods than low-quality diets (expressed per 100 g), high-nutritional quality diets ultimately had a stronger impact since they contained more food. Of course, further research is required to shed light on the connections between the GHGE of diets and nutritional sustainability. Few research has so far used cohort data to identify potential correlations between the sustainability elements of the environment, health, and nutrition (Colley TA. 2022).

The use of observational cohort data to analyze the carbon footprints of diets, rather than just national averages as is frequently done, is the main advantage of the present study compared to earlier studies of a similar nature on the general population. Furthermore, relationships between diet-related GHGE and nutritional sustainability may differ in certain communities, such as young people attending university, who have different consumption habits and dietary needs than the general adult population. As far as we are aware, no studies have previously examined these two sustainability aspects of college students' meals (Lisbeth Mogensen. 2022).

One of the most popular approaches for assessing the EnvI of foods and diets throughout the food chain is life cycle assessment (LCA). A good methodology for locating priority regions, sometimes known as environmental hotspots, is life cycle assessment. Food processing, entire food groupings, or the region of food options can all be hotspots. Past LCA research that computed the EnvI of individual foods highlighted the negative environmental effects of meat, particularly red meat. Recent LCA studies have emphasized modeled diets or typical dietary patterns. In a 2014 analysis of various eating habits, Scarborough et al. discovered a difference between high meat eaters and vegans (7.19 kg CO2 eq/d and 2.89 kg CO2 eq/d, respectively).

1.6. Nutritional requirements in athletes:

For optimal health and training adaptation to increase performance capacity, sports nutrition guidelines for athletes are higher for energy and the majority of macro- and micronutrients than for the general population. Based on varying training loads, there are specific recommendations for increasing calorie, carbohydrate, and fat consumption. Athletes should consume between 1.2 and 2 g of protein per kilogram per day, or 0.3 g per kilogram per day, which is 150–250% more than what is advised for the normal individual. Higher protein intakes have occasionally been suggested and found in athletes' diets.

Furthermore, to improve muscle protein synthesis and encourage muscle tissue repair, high-quality protein sources that contain essential amino acids, particularly leucine, are advised by sports nutrition guidelines. Because of this, animal and particularly dairy protein has been given top priority in sports nutrition, particularly post-exercise. There is very little information on the impact of individual or combination plant protein sources on the synthesis of muscle proteins. Therefore, it is not surprising that when the AP was validated, a higher-than-recommended amount of protein, particularly animal protein, was also discovered.

Given that animal proteins have a greater EnvI than plant proteins, it seems logical to research EnvI coupled with the effects of athletes' diets on their health and performance. Furthermore, it is well known that Westernized nations consume more protein overall and meat in particular than is advised. There are a lot of worries that active, westernized populations consume protein, and specifically meat, in quantities beyond what is necessary for optimum health, muscular development, and performance, while also hurting the environment because protein recommendations for athletes are almost two times higher than those for non-athletes (Chang. 2014).

1.7 Methods to determine the carbon footprint of food:

To determine the CF of foods, many methods have been employed, with attributional and consequential Life Cycle Assessment: Attribution Life Cycle Assessment (aLCA) and consequential Life Cycle Assessment (cLCA) being two of the most notable examples. In most cases, aLCA uses average data while cLCA uses marginal data. While LCA calculates the effects of manufacturing an extra unit, ALCA calculates the impact of the actual production. An aLCA will often be built on a bottom-up methodology, where studies on particular food products take into consideration all processes inside the established system limits. The Product Environmental Footprint Category Rules of the European Commission employ this strategy. In contrast, the top-down strategy relies on input-output analysis, an economic technique, and presupposes a connection between cost and environmental impact (West BT,2008).

This strategy is based on statistical information, such as that collected at the national level, which is subsequently separated to represent the particular steps of the product in question. Despite concluding that top-down approaches typically overestimate impacts, a paper comparing top-down and bottom-up approaches at various scales (such as consumption and consumers in the EU) revealed convergence of the results. According to three different techniques of calculation—a literature analysis of food life cycle assessment studies and production- and consumption-based input-output tables (IOT) made with the Japanese IOT—Sugimoto et al. demonstrated that the diet-related GHG emissions of Japanese diets varied. Others have shown variations in food composition factors (CF) and diet composition factors (DF) (Alegria-Lertxundi I, 2022).

1.8 Micronutrient and Macronutrient Requirements by the Athletes:

Athletes require more energy and protein than the average person. The amount of energy and protein an athlete needs depends on age, gender, body size, and activity level. Generally, athletes need more energy and protein than average to fuel their workouts and support muscle growth and repair.

Energy: The amount of energy an athlete needs depends on their activity level. Generally, athletes need more energy than the average person to fuel their workouts. The American College of Sports Medicine recommends that athletes consume 1.2-2.0 grams of carbohydrates per kilogram of body weight per day.

Protein: The amount of protein an athlete needs depends on their activity level and body size. Generally, athletes need more protein than the average person to support muscle growth and repair. The American College of Sports Medicine recommends that athletes consume 1.2-2.0 grams of protein per kilogram of body weight per day.

Carbohydrates: The amount of carbohydrates an athlete needs depends on their activity level and body size. Generally, athletes need more carbohydrates than the average person to fuel their workouts and support muscle growth and repair. The American College of Sports Medicine recommends that athletes consume 45-65% of their total calories from carbohydrates.

Fat: The amount of fat an athlete needs depends on their activity level and body size. Generally, athletes need more fat than the average person to provide energy and support hormone production. The American College of Sports Medicine recommends that athletes consume 20-35% of their total calories from fat.

Previous studies have demonstrated that plant-based diets, such as vegetarian and vegan diets, result in fewer greenhouse gas emissions (GHGE) than diets high in animal products. This conclusion has been demonstrated using both nationally suggested diets and diets based on aggregate intake using data on food availability but adjusted to match recommended diets. Potential decreases in GHGE have also been shown by modeling the effects of switching from meat to more plant proteins. The research has generally not placed a strong emphasis on studies based on specific diets, in part due to the difficulty of connecting the effects of hundreds of different dietary choices to the environment (West BT,2008).

Using meal frequency data, Scarborough et al. looked at vegans, vegetarians, fish eaters, and meat eaters in the UK and discovered that GHGE was lowest in vegan and vegetarian diets. Additionally, Seventh-Day Adventists in the US have demonstrated that vegetarian and semi-vegetarian diets have lower carbon footprints than non-vegetarian diets. Other studies that looked at the carbon footprints of diets consumed by people in Lebanon, Lebanon, or Spain discovered that GHGE was lower among diets that adhered more to a Mediterranean-style diet than among other diets in those nations (Sovacool et al., 2021)

Numerous studies have estimated the impact of dietary changes in the West towards more sustainable patterns based on GHG emissions, which are measured as the carbon footprint (CF). For instance, switching from ruminant meat to meat with a lower GHG effect or replacing some of the meat and dairy in your diet with plant-based alternatives has been shown to reduce your diet's overall caloric intake by 20% to 40%. Similar changes to those recommended by the official FBDG, such as reducing the amount of meat, especially ruminant meat, and increasing the number of legumes in meals, have been found to have a reduction potential of 25% in GHG emissions for food purchased by both child care centers and nursing homes.

Need of the study:

The carbon footprint is also an important component of the Ecological Footprint since it is one competing demand for biologically productive space. Carbon emissions from burning fossil fuels accumulate in the atmosphere if there is not enough biocapacity dedicated to absorb these emissions. A significant source of greenhouse gas emissions is food waste. This is because discarded food releases methane, a particularly potent greenhouse gas when it decomposes in landfills. Methane is thought to have a 34 times greater effect on global warming than carbon dioxide over a century.

The need for this study is to understand the impact of food choices on the carbon footprint of athletes. With the increasing awareness of climate change, athletes are increasingly looking for ways to reduce their environmental impact. This study will provide insight into how food choices can help reduce the carbon footprint of athletes and provide guidance on how to make more sustainable food choices. Additionally, this study will provide a better understanding of the environmental impact of different types of food and how they can be used to reduce the carbon footprint of athletes.

Athletes' requirement for protein is higher and animal-based product has a high amount of protein that contributes to high carbon emission. There is a research gap in the literature pertaining availability of data that looked at the carbon footprint of an athlete’s diet in an Indian Context and therefore the present study was conducted with the primary aim of assessing the carbon footprint of food in an athlete’s diet.

Aim: To estimate the Carbon footprint of the diet of 15-30-year-old athletes involved in different sporting activities

Objective:

- To assess the total carbon footprint of the diet of athletes playing football and Mixed Martial Arts (MMA)
- To compare the carbon footprint of different food groups in athletes' diet
- To recommend alternatives with a reduced carbon footprint

Chapter 2. Review of Literature

2.1 Various factors that contribute to the carbon footprint of food

The carbon footprint of food production and consumption is determined by a variety of factors. Agricultural practices, such as the use of fertilizers and pesticides, can have a significant impact on the carbon footprint of food. Additionally, the transportation and packaging of food products can also contribute to the carbon footprint. Finally, food waste is a major contributor to the carbon footprint of food, as wasted food still requires energy and resources to produce. All of these factors contribute to the overall carbon footprint of food production and consumption (Luxembourg, 2019).

The Carbon Dioxide Equivalent (CO_2e) is a measure of the global warming potential of a given greenhouse gas relative to carbon dioxide (CO_2). It is used to compare the emissions of different greenhouse gasses on a common scale and to calculate the total emissions of all greenhouse gasses in a given area. CO_2e is calculated by multiplying the mass of a given gas by its global warming potential (GWP). The GWP is a measure of how much energy the gas absorbs over a given period, relative to carbon dioxide. For example, methane has a GWP of 28, meaning that it absorbs 28 times more energy than carbon dioxide over the same period. Therefore, one ton of methane is equivalent to 28 tons of CO_2e (Xu et al., 2020).

2.2 Carbon footprint in various food groups

2.2.1 Cereals

The carbon footprint of cereals is the total amount of greenhouse gasses (GHGs) emitted during the production, packaging, and transportation of the cereal. This includes emissions from the burning of fossil fuels used to power machinery, as well as emissions from the production of packaging materials. The carbon footprint of cereals also includes emissions from the transportation of the cereal from the factory to the store. The carbon footprint of cereals is affected by a variety of factors, including the type of cereal, the production process, and the transportation methods used.

For example, cereals that are produced using organic farming methods tend to have a lower carbon footprint than those produced using conventional farming methods. Additionally, cereals that are transported by air or truck will have a higher carbon footprint than those transported by rail or ship. The carbon footprint of cereals can also be reduced by using more efficient production processes and packaging materials. For example, using lighter packaging materials or switching to renewable energy sources can help reduce the carbon footprint of cereals. Additionally, reducing food waste and using more efficient transportation methods can also help reduce the carbon footprint of cereals (Vita et al., 2020)

2.2.2 Vegetables and fruits

A carbon footprint is the total amount of greenhouse gasses (GHGs) emitted directly and indirectly by an individual, organization, event, or product. It is measured in units of carbon dioxide (CO_2) equivalent. Vegetables have a carbon footprint because they require energy to be grown, harvested, and transported. The carbon footprint of vegetables depends on the type of vegetable, how it is grown, and how it is transported. For example, organic vegetables typically have a lower carbon footprint than conventionally grown vegetables because they are grown without the use of synthetic fertilizers and pesticides, which require energy to produce. The carbon footprint of vegetables also depends on how they are transported (Kause et al., 2019).

For example, locally grown vegetables have a lower carbon footprint than those that are shipped from far away. Additionally, the type of transportation used to ship vegetables can affect their carbon footprint. For example, shipping vegetables by air has a higher carbon footprint than shipping them by truck or train. Finally, the carbon footprint of vegetables can be reduced by reducing food waste. Food waste is a major source of GHG emissions, so reducing food waste can help reduce the carbon footprint of vegetables. In summary, the carbon footprint of vegetables depends on the type of vegetable, how it is grown, and how it is transported. Additionally, reducing food waste can help reduce the carbon footprint of vegetables (Obersteiner et al., 2021).

2.2.3 Pulses and nuts:

The carbon footprint of pulses and nuts is the total amount of carbon dioxide (CO_2) and other greenhouse gasses emitted during the production, processing, transportation, and consumption of these foods. Pulses and nuts are a major source of protein in many diets, but their production can have a significant environmental impact. Pulses and nuts are grown in a variety of climates and soils, and the production process can vary significantly depending on the type of crop and the region in which it is grown (Zhang et al., 2019).

For example, pulses and nuts grown in tropical climates may require more water and fertilizer than those grown in temperate climates. This can lead to higher emissions of CO_2 and other greenhouse gasses. The transportation of pulses and nuts also contributes to their carbon footprint. These foods are often shipped long distances, which can lead to increased emissions of CO_2 and other greenhouse gasses. Additionally, the packaging used to transport these foods can also contribute to their carbon footprint. Finally, the consumption of pulses and nuts can also contribute to their carbon footprint. For example, cooking pulses and nuts can lead to increased emissions of CO_2 and other greenhouse gasses.

Additionally, the disposal of unused or spoiled pulses and nuts can also lead to increased emissions of CO2 and other greenhouse gasses. Overall, the carbon footprint of pulses and nuts is significant, and reducing this footprint is an important part of creating a more sustainable food system. By reducing the amount of water and fertilizer used in production, minimizing transportation distances, and reducing food waste, we can reduce the carbon footprint of pulses and nuts (Heusala et al., 2020).

2.2.4. Milk and dairy products:

A carbon footprint is the total amount of greenhouse gasses (GHGs) emitted directly and indirectly by an individual, organization, event, or product. In the case of milk and milk products, the carbon footprint includes emissions from the production of feed for dairy cows, the transportation of feed and milk, the processing of milk into products such as cheese and yogurt, and the packaging and distribution of these products. The production of feed for dairy cows is a major contributor to the carbon footprint of milk and milk products (Bradu et al., 2022).

The production of feed requires energy for irrigation, fertilizer, and other inputs, and the burning of fossil fuels to power farm machinery. Additionally, the transportation of feed from farms to dairy farms adds to the carbon footprint. The transportation of milk from dairy farms to processing plants also contributes to the carbon footprint. Milk is typically transported by truck, which requires burning fossil fuels. The processing of milk into products such as cheese and yogurt also requires energy for pasteurization, homogenization, and other processes. Finally, the packaging and distribution of milk and milk products add to the carbon footprint (Agregán et al., 2023).

Packaging materials such as plastic and cardboard require energy for production, and the transportation of these products from processing plants to stores also requires burning fossil fuels. Overall, the carbon footprint of milk and milk products is significant. However, some steps can be taken to reduce this footprint, such as using renewable energy sources for production and transportation and reducing packaging materials (Gabrielli et al., 2020).

2.2.5 Meat:

A carbon footprint is a measure of the total amount of greenhouse gasses (GHGs) emitted directly and indirectly by an individual, organization, event, or product. In the case of meat, the carbon footprint is the total amount of GHGs emitted from the production, processing, packaging, transportation, and consumption of meat products. The production of meat is a major contributor to global GHG emissions. Livestock production accounts for 14.5% of global GHG emissions, making it one of the largest sources of GHG emissions. This is due to the large amount of energy and resources required to produce, process, package, and transport meat products.

The production of meat also contributes to land and water degradation, deforestation, and biodiversity loss. Livestock production is responsible for 70% of global agricultural land use and is a major driver of deforestation in many parts of the world. Additionally, livestock production is a major source of water pollution due to the large amounts of manure and other waste produced. The consumption of meat also contributes to GHG emissions. The production of meat requires energy and resources, and the consumption of meat requires additional energy and resources for cooking, packaging, and transportation(Lin et al., 2022; Ou et al., 2022).

Additionally, the disposal of meat waste contributes to GHG emissions. Overall, the carbon footprint of meat is significant and contributes to global GHG emissions, land and water degradation, deforestation, and biodiversity loss. Reducing the consumption of meat is one way to reduce the carbon footprint of meat and help mitigate the effects of climate change(Liu et al., (2016).

2.2.6 Confectionaries:

A carbon footprint is the total amount of greenhouse gas emissions that are caused by an individual, organization, event, or product. In the confectionery industry, a carbon footprint is the total amount of greenhouse gas emissions that are caused by the production, packaging, transportation, and disposal of confectionary products. The production of confectionery products requires energy to operate machinery and equipment, as well as to heat and cool buildings. This energy use can result in the release of carbon dioxide, methane, and other greenhouse gasses. Packaging materials such as plastic and cardboard also require energy to produce and can result in the release of greenhouse gasses.

Transportation of confectionary products also contributes to a company's carbon footprint. The fuel used to transport products from the factory to the store or customer releases carbon dioxide into the atmosphere. Finally, the disposal of confectionary products can also contribute to a company's carbon footprint. If products are not disposed of properly, they can release methane and other greenhouse gasses into the atmosphere.

Companies in the confectionary industry can reduce their carbon footprint by using more efficient production processes, switching to renewable energy sources, and reducing their reliance on transportation. They can also reduce their packaging materials and ensure that products are disposed of properly. By taking these steps, companies in the confectionery industry can reduce their carbon footprint and help protect the environment.

2.2.7. Supplements:

A carbon footprint is the total amount of greenhouse gasses (GHGs) emitted directly and indirectly by an individual, organization, event, or product. It is measured in units of carbon dioxide equivalent (CO2e). The carbon footprint of supplements is the total amount of GHGs emitted during the production, packaging, transportation, and disposal of the supplement. The production of supplements involves the use of energy to manufacture the ingredients and package them into a finished product.

This energy use can come from burning fossil fuels, which release GHGs into the atmosphere. The transportation of supplements from the manufacturer to the retailer also requires energy, which can come from burning fossil fuels. Finally, the disposal of supplements can also result in GHG emissions, depending on the method of disposal. The carbon footprint of supplements can be reduced by using more efficient production processes, reducing transportation distances, and using more sustainable packaging materials. Additionally, consumers can reduce their carbon footprint by purchasing supplements that are locally produced and packaged in recyclable materials et al., (2016).

2.3 Difference in Carbon footprint between Plant rich diet and Animal rich diet:

A carbon footprint is a measure of the total amount of greenhouse gasses (GHGs) emitted directly and indirectly by an individual, organization, event, or product. It is calculated by summing the emissions resulting from every stage of a product or service's lifetime (material production, manufacturing, use, and end-of-life disposal). In terms of diet, a plant-rich diet has a lower carbon footprint than an animal-rich diet. This is because plants require fewer resources to produce than animals, and they emit fewer GHGs during their life cycle. Plant-based foods such as fruits, vegetables, grains, and legumes require less energy to produce than animal-based foods such as meat, dairy, and eggs(Pigou, (1920).

Additionally, plant-based foods are typically grown in more sustainable ways than animal-based foods, which often require large amounts of land and water resources. Animal-rich diets have a higher carbon footprint because of the resources required to produce them. Animal-based foods require more energy to produce than plant-based foods, and they also emit more GHGs during their life cycle.

Additionally, animal-based foods often require large amounts of land and water resources, which can lead to deforestation and water pollution. In conclusion, a plant-rich diet has a lower carbon footprint than an animal-rich diet due to the resources required to produce them. Plant-based foods require less energy and emit fewer GHGs, while animal-based foods require more energy and emit more GHGs. Additionally, animal-based foods often require large amounts of land and water resources, which can lead to deforestation and water pollution(Bruins and Létinois, 2021).

2.4 Carbon footprint emitted by athletes:

A carbon footprint is the total amount of greenhouse gasses (GHGs) produced by an individual, organization, or event. It is measured in units of carbon dioxide equivalent (CO2e). For athletes, their carbon footprint is the total amount of GHGs they produce through their activities, such as travel, training, and competition.

Travel: Athletes often travel to competitions and training camps, which can produce a significant amount of GHGs. Air travel is one of the biggest contributors to an athlete's carbon footprint, as it produces large amounts of CO2e. Other forms of travel, such as driving and taking public transportation, also contribute to an athlete's carbon footprint.

Training: Training for a sport can also produce GHGs. For example, running on a treadmill or using a stationary bike produces electricity, which can produce GHGs. Additionally, athletes may use equipment such as weights or resistance bands, which require energy to manufacture and transport (Parashar et al., 2020).

Competition: During competitions, athletes may use energy-intensive equipment such as lighting, sound systems, and video screens. Additionally, spectators may travel to the event, which can produce GHGs. Athletes can reduce their carbon footprint by using more sustainable forms of travel, such as taking public transportation or carpooling. They can also reduce their energy consumption by using energy-efficient equipment and turning off lights and other equipment when not in use. Additionally, athletes can offset their carbon footprint by investing in renewable energy sources or carbon offset projects.

2.5. Carbon footprint: Football vs Martial arts

A carbon footprint is a measure of the total amount of greenhouse gas emissions that are generated by an individual, organization, or activity. Football athletes have a larger carbon footprint than other sports athletes due to the amount of travel and energy required to play the sport. Football teams often travel long distances for away games, which requires the use of planes, buses, and cars. Additionally, football stadiums require a large amount of energy to power lights, scoreboards, and other equipment. This energy is typically generated from fossil fuels, which release carbon dioxide into the atmosphere.

Other sports, such as basketball and baseball, require less travel and energy, resulting in a smaller carbon footprint. Martial arts athletes have a much smaller carbon footprint than football athletes. Martial arts athletes typically train in a single location, such as a dojo or gym, and do not require any travel for competitions. Additionally, martial arts dojos and gyms require much less energy than football stadiums, as they are typically smaller and do not require the same level of lighting and equipment. As a result, martial arts athletes have a much smaller carbon footprint than football athletes (Morini et al., 2019).

2.6. Carbon footprint: Homemade food vs Outside food

A carbon footprint is the total amount of greenhouse gasses (GHGs) emitted directly and indirectly by an individual, organization, event, or product. It is measured in units of carbon dioxide equivalent (CO2e). When it comes to food, the carbon footprint of homemade food versus outside food can vary significantly. Homemade food typically has a lower carbon footprint than outside food because it is made with fewer processed ingredients and often uses locally sourced ingredients. This means that fewer resources are used to produce the food, resulting in fewer GHG emissions.

Additionally, homemade food is often cooked in smaller batches, which reduces the amount of energy used to prepare the food. On the other hand, outside food typically has a higher carbon footprint because it is often made with more processed ingredients and is often shipped from far away. This means that more resources are used to produce food, resulting in more GHG emissions.

Additionally, outside food is often cooked in larger batches, which increases the amount of energy used to prepare the food. Overall, homemade food typically has a lower carbon footprint than outside food. However, the exact carbon footprint of each type of food will depend on the ingredients used and the methods of preparation(Mikulčić et al., 2019).

2.7. Carbon footprint in Gels, supplements, and bars:

A carbon footprint is the total amount of greenhouse gasses (GHGs) emitted directly and indirectly by an individual, organization, event, or product. In the context of athletes' gel, supplements, and bars, the carbon footprint is the total amount of GHGs emitted during the production, packaging, transportation, and disposal of these products. The production of athletes' gels, supplements, and bars involves a variety of processes that can generate GHGs.

For example, the production of ingredients such as proteins, carbohydrates, vitamins, and minerals can generate GHGs through the use of energy and the release of emissions from manufacturing processes. Packaging materials such as plastic and cardboard can also generate GHGs through the production and transportation of these materials. Transportation of athletes' gels, supplements, and bars also generates GHGs. The transportation of these products from the manufacturing facility to the retail store or consumer generates GHGs through the burning of fossil fuels.

Additionally, the disposal of these products can generate GHGs through the release of methane from landfills. Overall, athletes' gels, supplements, and bars have a significant carbon footprint due to the production, packaging, transportation, and disposal of these products. Reducing the carbon footprint of these products can be achieved through the use of renewable energy sources, more efficient packaging materials and transportation methods, and the use of compostable packaging materials (Sovacool et al., 2021)

The development of Product Environmental Footprint Category Rules (PEFCRs) has taken several years, as evidenced by the EU Commission's 2021 recommendation "on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organizations". These PEFCRs work to standardize the LCA methodologies employed; for instance, they advise using aLCA studies and dLUC can be included if reported separately, however, iLUC cannot be included due to significant technique uncertainty. PEFCRs cover a wide range of effect categories, including ozone depletion, human toxicity (cancer and non-cancer), photochemical ozone generation (human health), eutrophication, acidification, freshwater ecotoxicity, terrestrial, freshwater, and marine, land use, and water usage impacts of biodiversity so far (Mikulčić et al., 2019).

STUDY TITLE	METHODS USED	KEY FINDINGS
Variations in greenhouse gas emissions of individual diets: Associations between the greenhouse gas emissions and nutrient intake in the United Kingdom (Rippin HL, Cade JE, Berrang-Ford L, Benton TG, Hancock N, et al. 2021)	The UK Composition of Items Integrated Dataset (COFID) composition tables were updated to include GHG emissions of specific foods, including process phases before retail, and automated online dietary evaluation for 212 persons across three 24-hour periods. The relationship between variations in GHG emissions and dietary habits, demographic data, and WHO Recommended Nutrient Intakes was examined (RNIs).	98% (n = 323) of the food products were connected to GHG emission estimations. 32% of diet-related GHG emissions were attributed to meat, 15% to beverages, 14% to dairy, and 8% to cakes, biscuits, and confections. GHG emissions were 59% (95% CI 18%, 115%) greater for non-vegetarian diets than for vegetarian ones. GHG emissions were 41% (20%, 64%) greater in men than in women. Compared to people who exceeded the RNI, those who met the RNI for saturated fats, carbs, and sodium had fewer GHG emissions.
Dietary greenhouse gas emissions of meat-eaters, fish-eaters, vegetarians and vegans in the UK (Scarborough et al., 2014)	Using a validated food frequency questionnaire, the diets of 2,041 vegans, 15,751 vegetarians, 8,123 fish eaters, and 29,589 meat eaters aged 20 to 79 were evaluated. Using a dataset of GHG emissions for 94 food items in the UK, with a weighting for the global warming potential of each component gas, comparable GHG emissions parameters were constructed for the underlying food codes. For each participant, the typical GHG emissions linked to a 2,000-kcal diet were calculated. The average dietary GHG emissions by diet group, adjusted for sex and age, were calculated using an ANOVA.	The average daily GHG emissions, adjusted for age and gender, were 7.19 for high meat eaters (>= 100 g/d), 5.63 for medium meat eaters (50-99 g/d), and 4.67 for low meat eaters. (To sum up, dietary GHG emissions are roughly twice as high in self-selected meat eaters as they are in vegans.)

Carbon footprint of self-selected US diets: nutritional, demographic, and behavioral correlates (Donald Rose, Martin C Heller, March 2019)	By connecting every meal eaten in participants' 24-hour recall diets to our new database of food environmental impacts, the dietary GHGE from US adults (>18 y, N = 16,800) in the 2005–2010 National Health and Nutrition Examination Survey (NHANES) was estimated. By GHGE/1000 kcal, diets were rated. The US Healthy Eating Index (HEI) and levels of particular nutrients known to be under- or over consumed in the US population were compared between those in the top and bottom quintiles. These dietary carbon footprints were also associated with demographic and behavioral NHANES characteristics.	Diets in the bottom quintile had considerably higher (P 0.001) HEI scores on a scale of 100 points, accounting for 2.3 0.7 points more emissions overall (GHGE/1000 kcal) than those in the top quintile. While high-GHGE diets had higher levels of vitamins A and D, choline, calcium, iron, and potassium, these low-GHGE diets had higher levels of fiber and vitamin E and lower levels of sodium and saturated fats. Low-GHGE diets included more poultry, plant protein sources, oils, whole and refined grains, and added sugars while consuming less meat, dairy, and solid fats.
Nutritional quality and carbon footprint of university students' diets: results from the EHU12/24 study (Ramón-Arbués, Enrique Granada-López, 2021)	Cross-sectional. A validated FFQ was used to analyze dietary consumption, and the Healthy Eating Index (HEI-2010) and MedDietScore were used to evaluate the quality of the diet (MDS). The literature was searched for GHGE data. Additionally, as factors, sex, socioeconomic level (SES), and body fat (BF) status were examined.	Low consumption of carbs (38–72% of total energy intake, or TEI) and high consumption of lipids (39–08% of TEI) were characteristics of student diets. The dietary quality of more than half of the subjects was poor. After adjusting for sex, SES, and BF status, participants with low HEI-2010 scores (: 0039 kg eCO2/1000 kcal/d) and high MDS scores (: 0023 kg eCO2/1000 kcal/d) were more likely to consume the low-emitting diets. Women and people with a normal BF % were more likely to consume the low-emitting and healthful diets.

Chapter 3: Methodology

This chapter outlines the methodology and specific research procedures used in the current study. This particular study was conducted to assess the carbon footprint of food in an athlete's diet using secondary data. The crucial headings in this chapter include the methodological specifics.

3.1 Participant information sheet

The participant sheet, which describes the specifics of the study was explained to the participants. They could use this information to decide whether or not to participate in the study. The sheet had information on the study's goals, requirements, benefits, and risks for participants. Appendix II with a participant sheet has been provided. A participant information sheet is a crucial component of a study's planning and execution. The participant information sheet provides prospective participants with an essential understanding of the purpose and methods of the study, as well as the sources of information to address any additional questions and enable them to provide informed consent.

3.2 Consent form

Before their participation, individuals signed a consent form. They were made to understand the study's goals and objectives. The study's questions and responses were all documented. They were free to leave the evaluation at any moment and without excuse. The material is essentially repeated on a consent form to make sure the important points are understood and this knowledge is then documented typically with a signature.

3.3 Study design

This was a secondary study design used to assess the carbon footprint of food which was taken from two of my colleagues.

3.4 Sample selection

The target population of the study was athletes mainly playing football and Martial arts (MMA) aged 15-30 years residing in Mumbai city.

3.4.1 Sampling technique

The sampling technique used for the study was Purposive Sampling. Purposive sampling, also known as subjective sampling, is a non-probability sampling technique in which the researcher uses their judgment to select variables for the sample population. Here, the researcher's judgment and understanding of the context determine every step of the sampling procedure. Purposive sampling, when used properly, aids the researcher in removing replies that are not pertinent to the study's objectives. After defining the requirements for systematic research based on clear goals and objectives, you can go on to selecting units or variables that can yield insightful results. One efficient way to choose samples is by purposeful sampling. To select the most suitable volunteers for the scientific experiment, the researcher here relies on their knowledge. It is also time effective.

3.4.2 Sampling size

The study was carried out on 100 participants aged 15-30 years and above athletes in the Central region of Mumbai.

3.4.3 Study duration

The duration of the study was 1 year and it is segregated as follows: -

● 1 month for research topic selection

● 2 months for Research Proposal generation, acquiring ethnic approval & Review of Literature, and Questionnaire generation.

● 2 months for piloting the tool and interpreting the results of the pilot study, as well as making necessary changes and finalizing the questionnaire.

● 3 months for administering the questionnaire to the actual population.

● 2 months for assembling, sorting, and cleaning the data and doing statistical analysis of the data.

● 2 months for interpretation of the data, finalizing and printing of the data.

3.5 Tools Used for data collection

Several tools were used to assess the diet, nutritional status, and its association with quality of life in the athletic population. A self-designed questionnaire consisting of different questions to acquire detailed information about the athletes along with a validated questionnaire was administered.

A brief description of the tools is as follows: -

3.5.1 Socio-Demographic status

In this study, the participant’s age, sex & socioeconomic status have been collected.

3.5.2 Socioeconomic Status (Kuppuswamy Scale 2022)

One of the most important factors to consider when assessing a family's health and nutritional state is their socioeconomic position. The social standing or social class of an individual or a group is known as socioeconomic status. The main factors considered are education, income, and occupation. As a result, it is one of the most important indicators to consider when assessing the nutritional and health state of a family. The socioeconomic situation has an impact on the community's morbidity and death rates as well. SES typically makes the diagnosis for the patient and his or her family. It enables accurate comprehension of the cost of healthcare, the amenities available to them, their purchasing power, and health-seeking behavior.

3.5.3 Anthropometric Assessment

An efficient and trustworthy method for assessing changes in nutritional status is anthropometry. It also offers a way to assess if nutritional therapy is being used appropriately. An individual's anthropometric measures are increasingly regarded as crucial markers of their nutritional state. The measurements taken in this study are: -

- Height in cm
- Weight in kg
- Waist Circumference in cm
- Body Fat Percentage in %
- Total Body water

- Basal Metabolic Rate (BMR) in kg/m2
- Resting Metabolic Rate (RMR) in kcal/d

a) Height: - The height of a person is measured from the bottom of their feet to the top of their head when they are standing straight. When using the metric or SI systems, it is measured with a stadiometer in centimeters; however, when using the US customary units or the imperial systems, it is measured in feet and inches.

b) Weight: - A person's mass or weight is their human body weight. Body weight is the measurement of weight without any things that are attached to the individual. However, it is possible to assess body weight using manual or digital weighing scales while wearing clothes, but without shoes or bulky accessories like purses and cell phones. A person's excess or decreased body weight is thought to be a sign of their health, and body volume measurement adds another dimension by assessing how that body weight is distributed.

c) Waist Circumference: - WC is the measurement used to categorize central obesity. The WC-mid is a more accurate way to measure central obesity. Standing up, one measures their waist by wrapping a measuring tape around the center, just above the hip bones. Make sure the waistband tape is horizontal. While maintaining a close fit around the waist, avoid squeezing the skin. As soon as you exhale, calculate the waist. For men (below 94.9cm) is considered normal, (95-1.1.9 cm) is high risk and (more than 102 is considered very high risk for obesity. For women (less than 80.9cm) is considered normal weight, (81-88.9cm) is considered high risk, and (more than 90cm) is categorized as very high risk for obesity.

d) **Total body water**: It is measured in athletes to assess hydration status, electrolyte balance, and energy metabolism. It can also be used to monitor changes in body composition, as well as to detect the presence of performance-enhancing drugs or other substances in the body. Measuring total body water is important for athletes because it allows them to maintain optimal hydration levels to prevent dehydration, optimize performance, and reduce the risk of injury.

3.5.4 Medical History

Details contained about a person's health are considered medical history. In a personal medical history, details concerning ailments, operations, vaccines, and the outcomes of physical examinations and tests may be included. Information on medications taken as well as health practices like diet and exercise may also be included. A person's immediate family members' health history can be included in their family medical history (parents, grandparents, children, brothers, and sisters). This covers both their present and previous ailments.

3.5.5 Food Frequency Questionnaire

A food frequency questionnaire (FFQ) includes a limited number of foods and drinks along with response options that indicate how frequently they are typically consumed during the period under consideration. FFQs are typically self-administered; occasionally, interviewers are used, for instance, when literacy levels are low. FFQs can be used to investigate links between diet and health. In this study, interview-based FFQ was administered according to the study’s age group.

3.5.6 24 Hour Diet Recall

A 24-hour dietary recall (24Hr) is a systematic interview designed to gather specific information about all the foods and drinks (as well as potential dietary supplements) that the respondent consumed over the previous 24 hours, most frequently from midnight to midnight the day before. The fact that the respondent is occasionally prompted for more specific information than what was first supplied is a significant component of the 24Hr.

3.7 Data Collection

Data collection included receiving responses to the questionnaire through face-to-face interview methods i.e. meeting the participant in person and collecting the data by going to their places and asking for their dietary recall and all the necessary information required for the research study by seeking their consent to participate in the study.

3.8. Formula to calculate carbon footprint:

Carbon Footprint of food OR Global Warming Potential Score (GWP)= [GWP per 100g of food (kg CO_2-eq) x Amount of Food (g)] / 100

(Shindell et al., 2009)

This is the way carbon footprint was calculated for every food item consumed by the participants in the study as collected by using the 24-hour diet recall.

There are standard databases that have compiled together the carbon footprint scores of different food items, and I used those databases to calculate the carbon footprint of food consumed by the participants in the study.

Demonstration of the above formula is as follows:

Recipe: Egg Biryani

Ingredients: Rice, Egg, Coriander, Veggies, Spices, oil

Carbon footprint: Rice (100g) = 4 * 100 / 100 = 4 Co2/eq

(100g is the amount of rice that has been taken, whose carbon footprint is 4 co2eq. therefore substituting those values into the formula. Similar steps were repeated for the other ingredients as well to get the results).

Ingredients	Carbon score
Rice(100g)	4
Veggies (50g)	1
Egg (50g)	2
Oil (8g)	0.64

By substituting all the values in the formula for other ingredients as well, the carbon footprint for vegetables(50g) was 1, egg- 2, oil(8g) – 0.64, and rice(100g) – 4 Co2eq. By adding up all the values we get **the Total Carbon footprint score for Egg biryani: 4+1+2+0.64 = 7.64 Co2eq**

Chapter 4: Results and Discussion

Table 4.1: Demographic data

Variables	Categories	n(n%)
Age	15-20 years	68(57.8)
	21-25 years	17(14.4)
Gender	Males	88(74.8)
	Females	12(10.2)
Occupation	Unemployed	95(80.7)
	employed	5(4.2)
Education status	Middle school certificate	5(4.2)
	High school certificate	30(25.5)
	Intermediate or diploma	35(29.7)
	Graduate	10(8.5)
	Profession or honors	0
Monthly Income (Rs)	<100001	4
	100002 - 200001	12
	200002 - 400001	16
	400002 - 700001	20
	700002 - 900001	9
	900002 - 1000001	16
	>1000001	8
Sports category	MMA	12(10.2)

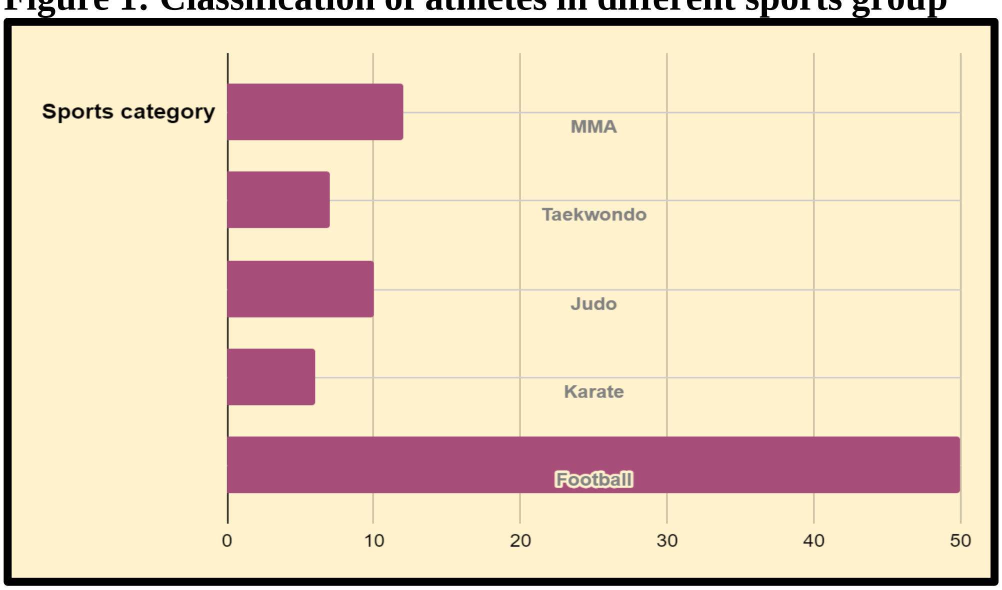
	Taekwondo	7(5.95)
	Judo	10(8.5)
	Karate	6(5.1)
	Football	50(42.5)
Eating preference	Veg	19(19)
	Non-Veg	56(56)
	eggiterian	10(10)
Total Training hours		2.5 hours

Table 4.1 presents the demographic data of the athletes who participated in the study; whose ages range from 15 to 30 years. Of all participants, 57.8% were between the ages of 15 and 20 years, and 14.4% were between the ages of 21 and above. Of the total participants, 74.8% were men and 10.2% were women. The majority of the participants that is 40% and 45% were from high school, and/or diplomas because they were primarily between the ages of 15-20 years.

The study's primary sports categories were football and martial arts, with football accounting for 65.5% of the total participants, MMA, Taekwondo, Judo, and karate were included.
The Mean Training hours of the athletes were 2.5 hours including pre-training and post-training sessions. The eating preference of the majority of the participants was a nonvegetarian diet (55%), followed by vegetarians (25%) and egg eaters (10%).

The results showed that the highest percentage of participants with an annual income between 400002 – 700001(20%), 200002 - 400001 (16%), 900002 - 1000001(16%); followed by the annual income of less than 100001 (4%), 100002 - 200001(12%), 700002 - 900001 (9%) and lastly more than 1000002 (8%).

Figure 1: Classification of athletes in different sports group



The results showed that the majority of participants played football followed by mixed martial arts (MMA), such as Martial arts, Karate, Judo, and Taekwondo. Participants playing football were 65.5% of the total athletes and; Mixed Martial Arts constituted about 14.5%, followed by 11.5% for Judo, 4.5% for Taekwondo, and 3.5% for Karate.

Table 4.2: Anthropometric data:

Variable	Mean
Height(cm)	165 (9.19)
Weight (kgs)	59 (11.8)
Body fat percentage (%)	28 (7.7)
Muscle mass (kg)	46 (6.3)
BMR (kcal/m2/h)	1544 (7.9)
RMR (kcal/d)	1440 (6.5)

The results showed the anthropometric data of the participants in the study with a mean height of 165cm (9.19), followed by weight (59 kg), body fat percentage (18%), muscle mass (46), RMR (1440), BMR (1544), and total body water (60.38).

Body fat percentage is taken into account when calculating a person's carbon footprint because it is an indicator of how much energy the body needs to function. People with higher body fat percentages require more energy to maintain their body weight, which in turn increases their carbon footprint. Additionally, people with higher body fat percentages tend to have higher caloric intakes, which also increases their carbon footprint (Rondoni and Grasso, 2021).

The range of body fat percentage for men is typically between 8-19%, while the range for women is typically between 21-33%. Here the body fat percentage of males (28%) and females (18%) falls under the normal range.

According to Nordic Nutrition Recommendations 2012, **BMR (Basal Metabolic Rate) and RMR (Resting Metabolic Rate)** are used to calculate the carbon footprint of athletes because they are measures of the amount of energy an athlete needs to maintain basic bodily functions. This energy is typically derived from food, which is a major source of carbon emissions. By calculating an athlete's BMR and RMR, it is possible to estimate the amount of carbon emissions associated with their diet and lifestyle. According to the normal range athlete aged 20-29 may have a BMR of 1,800-2,400 kcal/day and an RMR of 1,400-2,000 kcal/day. Therefore, the mean values fall under the normal category.

Total body water is used to calculate the carbon footprint in athletes because it is a measure of the amount of energy an athlete expends during physical activity. This energy expenditure is directly related to the amount of carbon dioxide released into the atmosphere, which is a major contributor to global warming. By measuring total body water, researchers can accurately estimate the amount of carbon dioxide released by an athlete during physical activity and calculate their carbon footprint.
The normal range of total body water in athletes is typically between 45-65%. And according to the data the total body water is 60.38% which falls under the normal range; therefore, the carbon footprint is normal (Rondoni and Grasso, 2021).

Table 4.3: Analysis of Macro and Micronutrient Intake from 24-Hour Diet Recall:

Nutrients	Mean
Energy (kcal)	1871.35 (875.5)
Carbohydrate (g)	217 (111.30)
Protein (g)	70.23 (41.91)
Fat (g)	73.13 (40.07)
Calcium (g)	505.62 (354.05)
Fiber (g)	23.66 (13.96)

The results in the above table show the total macronutrient and micronutrient distribution throughout the day of the athlete's diet from the 24-hour diet recall that was recorded during the study. The carbon footprint of macronutrients and micronutrients of food in a 24-hour diet recall depends on the type of food consumed.

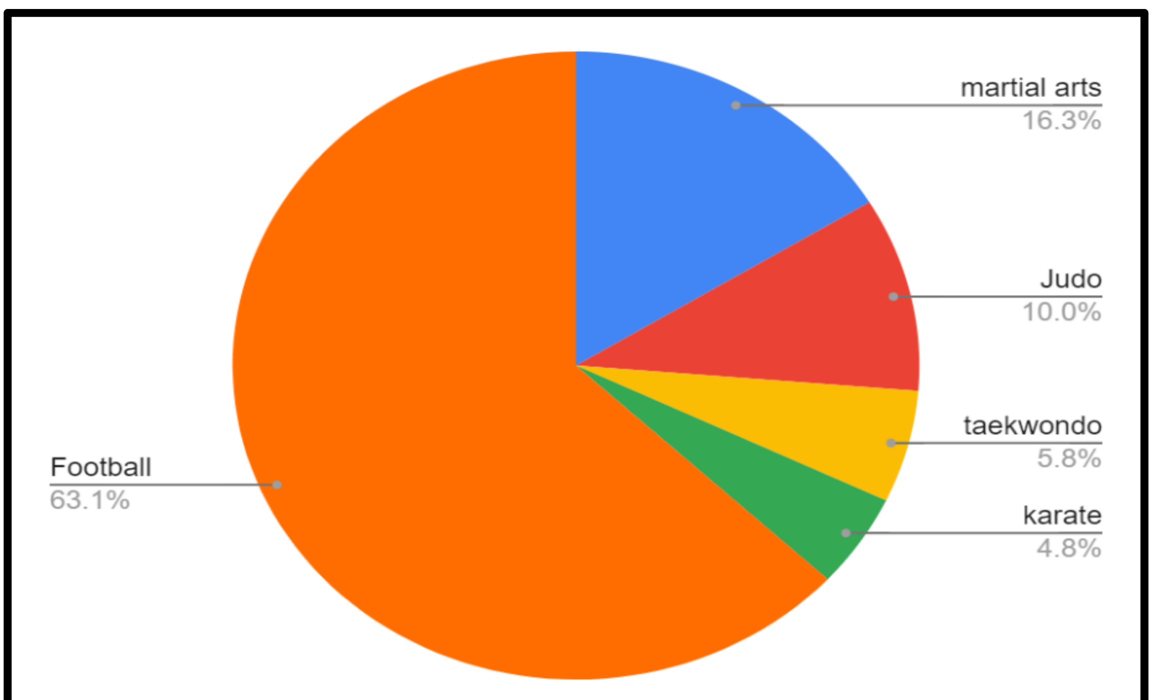


Fig. 4.4: Comparing total Carbon Footprint in two different sports:

The results indicate that the highest carbon footprint came from the participants playing football (63.1%) followed by Mixed martial arts; Martial Arts (16.3%), Judo (10%), Taekwondo (5.8%), and Karate (4.8%).

This significant difference in carbon footprint between the football players and MMA players was because participants playing football were in the majority and football is also considered to be an energy-intensive sport, therefore its carbohydrate and protein intake is higher leading to high carbon emission than mixed martial art participants.

Table 4.5: Analysis of Meal Wise Carbon Footprint from 24-Hour Dietary Recall:

Meals	**Mean**
Early morning	1.032 (0.63)
% of total daily CF	5%
Breakfast	13.904 (4.47)
% of total daily CF	25%
Mid-morning	0.961 (0.62)
% of total daily CF	5%
Lunch	13.87 (3.77)
% of total daily CF	30%
Snacks	13.12 (1.77)
% of total daily CF	10%
Dinner	16.18 (5.10)
% of total daily CF	25%

The results in Table 4.5 showed the overall distribution of the carbon footprint throughout the day. Considering all the meals the highest carbon footprint is among 3 main meals that are **breakfast, lunch, and dinner** that is 25%, 30%, and 25% respectively, and for the other meals are **snacks, midmorning and early morning** is 10%, 5% and 5% respectively.

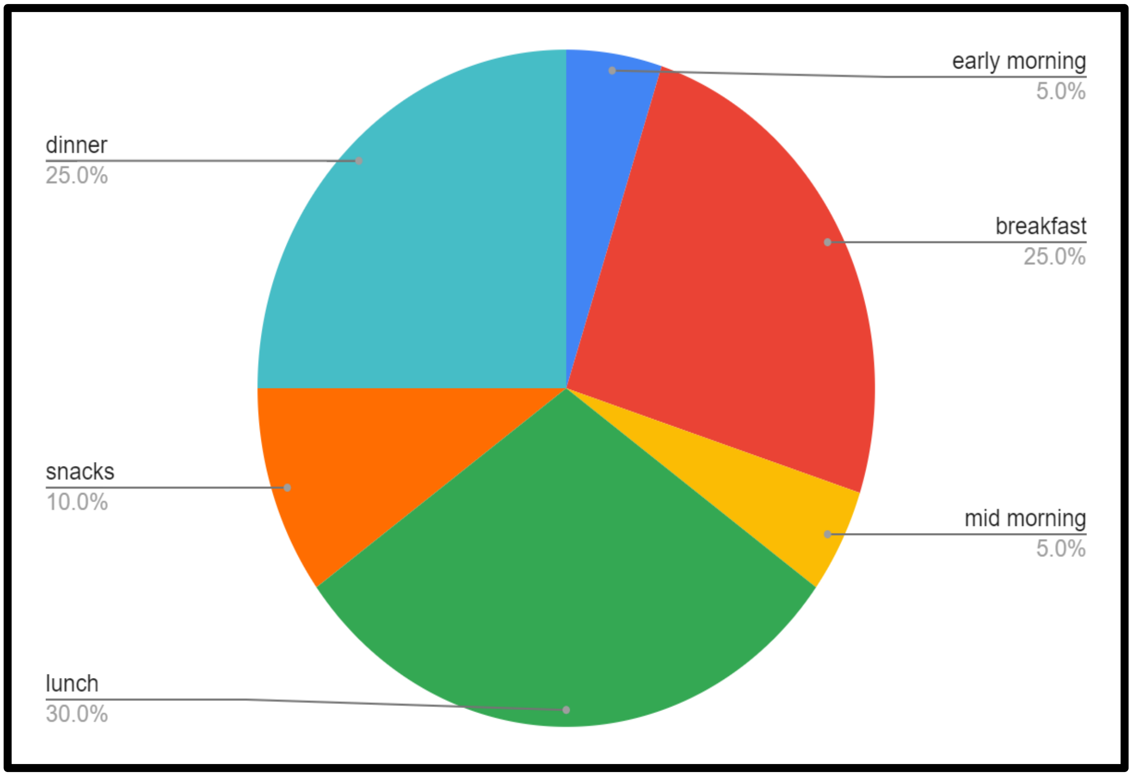


Figure 4.4: Analysis of Meal Wise Carbon Footprint from 24-Hour Dietary Recall:

According to Arrieta and González, 2019, Carbon footprints tend to be higher during breakfast, lunch, and dinner because these meals typically involve more energy-intensive activities such as cooking, heating, and refrigeration. Additionally, these meals often involve more food waste, which can contribute to a higher carbon footprint.

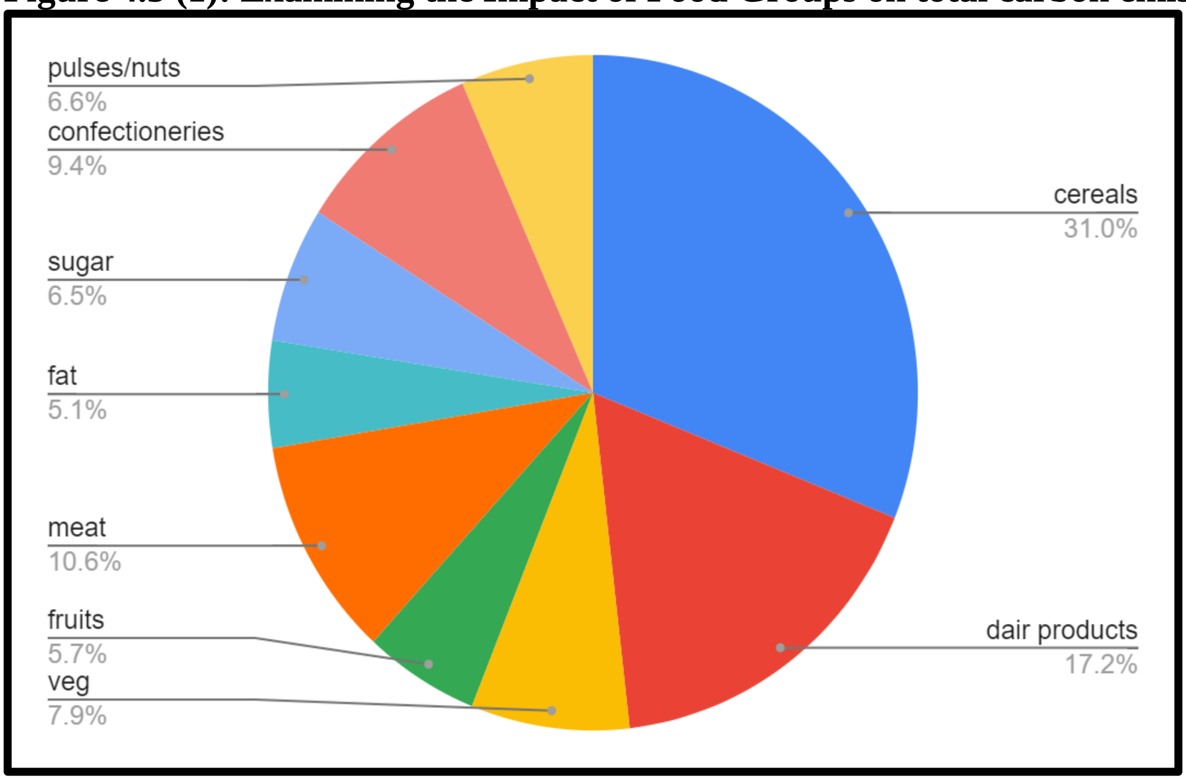
And it is evident from Fig. 4.4 that the three big meals of the day—breakfast, lunch, and dinner—are when carbon emissions are highest because these are the times when we tend to eat the most food overall.

Table 4.5: The Influence of Different Foods on the Total Environmental Impact

	Total Food Group Carbon Footprint		
Food groups	**Mean**	**sub food group**	**% of CF in sub food group**
Cereals % of total CF = 31	216.6(1.06)	Rice Wheat Oats Others	14% 8.5% 3.5% 5.5%
Dairy products % of total CF =17.2	129.34(0.62)	Milk Paneer Cheese Other	7% 5% 3% 2%
Vegetables % of total	58.22(0.52)	All vegetables	7.9%

CF =7.9			
Fruits % of total CF =5.7	42.54(0.49)	Apple Banana Watermelon	2.5% 2.5% 0.7%
Meat % of total CF =10.1	70.32(2.63)	Chicken Mutton	8% 2.1%
Pulses/nuts % of total CF = 7	45.86(0.48)	Pulses Nuts	3.5% 3.5%
Confectionaries % of total CF =9.4	65.58(0.30)	Biscuits, maggi, beverage Supplements/gels/bars	3.2% 6.2%
fat/oil % of total CF =5.1	38.02(25.22)	Butter Ghee Oil	1.5% 2.3% 1.3%
Sugar % of total CF =6.6	48.14(15.25)		6.6%

Figure 4.5 (1): Examining the Impact of Food Groups on total carbon emission:



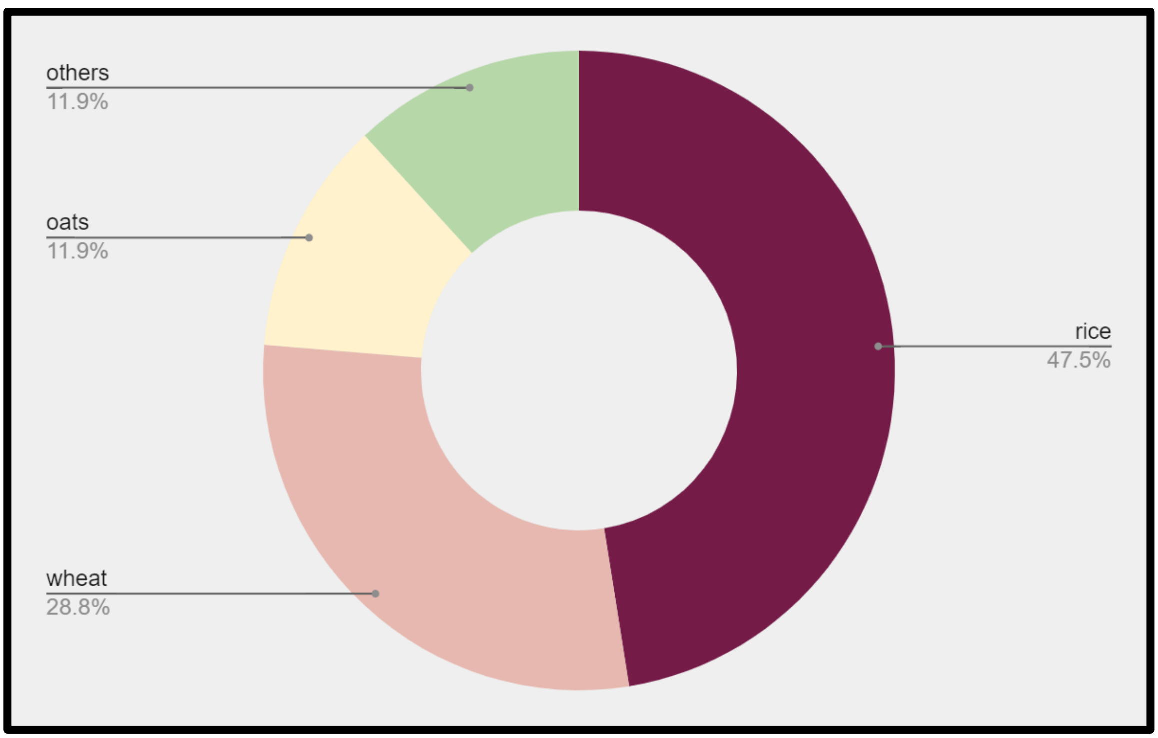
The results showed the list of every food category that was recorded during the 24-hour diet recall. The majority of participants consumed cereals (31%), which resulted in the highest greenhouse gas emission, followed by dairy (17.2%), meat (10.1%), confectionery (9.4%), pulses and nuts (7%), vegetables(7.9), fruits (5.7%), sugar (6.6%), and fats and oils (5.1%).

According to a study by Scarborough et al., 2012, The carbon footprint of sub-food groups is important to look at because it can help us understand the environmental impact of our food choices. By understanding the carbon footprint of different food groups, we can make more informed decisions about what we eat and how it affects the environment. For example, if we know that a certain food group has a high carbon footprint, we can choose to reduce our consumption of that food group or look for more sustainable alternatives. This can help us reduce our overall carbon footprint and contribute to a healthier planet.

However, for better understanding, the major food groups were divided into their subcategories. The main staple cereals, such as rice, wheat, and oats, contributed to the highest percentage of the carbon footprint from the total emission of cereals. Confectionaries contributed to 9.4 percent of total emissions but from which the highest part came from supplements, bars, and gels that athletes consumed during their match and training sessions, followed by other junk as Maggi, biscuits, and beverages constituted 3.2% of total carbon emission from total confectionaries.

Followed by milk and dairy products, milk, paneer, and cheese contributed to the highest carbon footprint as compared to the other dairy products. Highly consumed fruits, such as apples, bananas, and watermelon contributed about 2.5%, 2.5%, and 0.7% of the total carbon emission respectively. From Pulses/nuts category, sprouts and pulses contributed to 3.5% of the total pulses and nuts carbon footprint emission. The majority of athletes chose ghee over butter and other types of oil when it came to fats and oils.

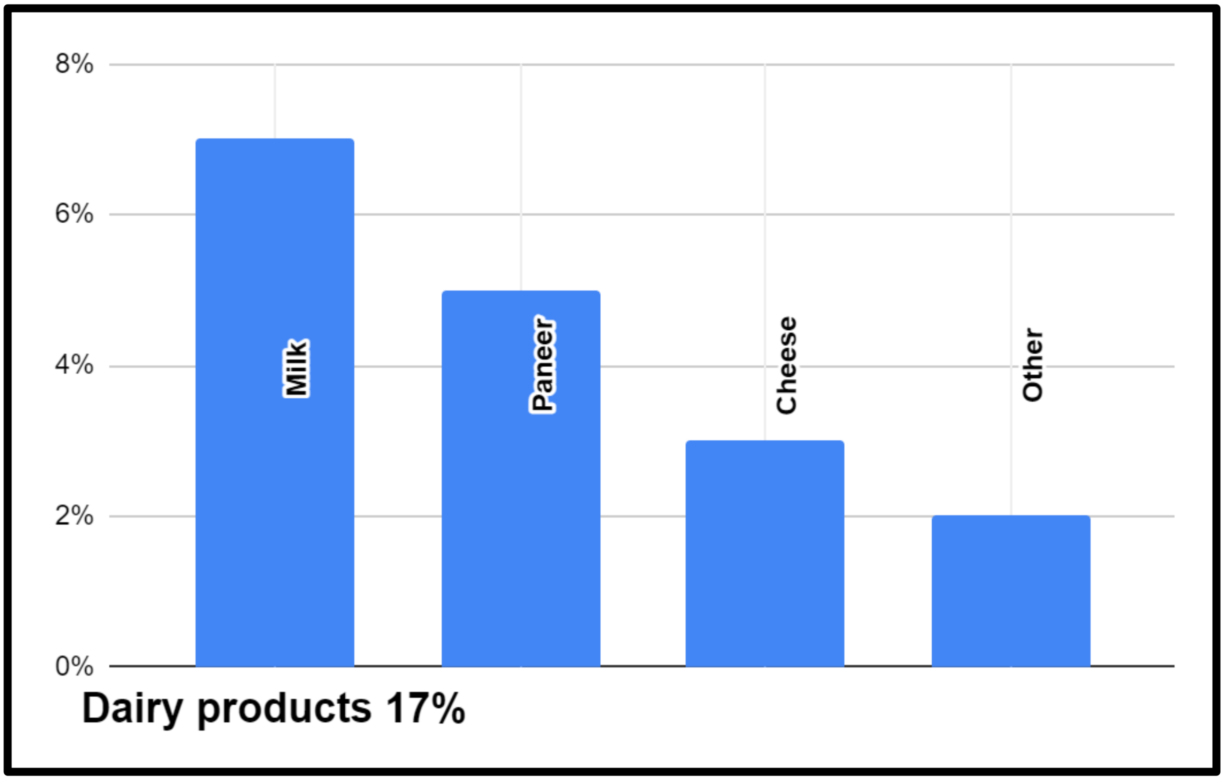
Figure 4.5 (2): Analysis of staple cereals to the total percentage of cereals carbon emission



The results indicated that the majority of the participants in the study consumed rice, wheat, and oats compared to other cereals, which resulted in higher carbon emissions than other cereals. According to a study by Vauterin et al., 2021, the Carbon footprint in cereals like wheat, rice, and oats is largely determined by the production methods used. For example, the carbon footprint of wheat is higher when it is produced using conventional farming methods that rely heavily on chemical fertilizers and pesticides. On the other hand, organic farming methods that use natural fertilizers and pest control can reduce the carbon footprint of wheat production.

Similarly, the carbon footprint of rice and corn can be reduced by using sustainable farming practices such as crop rotation, cover cropping, and integrated pest management.

Figure 4.5 (3): Analysis of Milk and Dairy products to the total Dairy carbon emission by the consumption

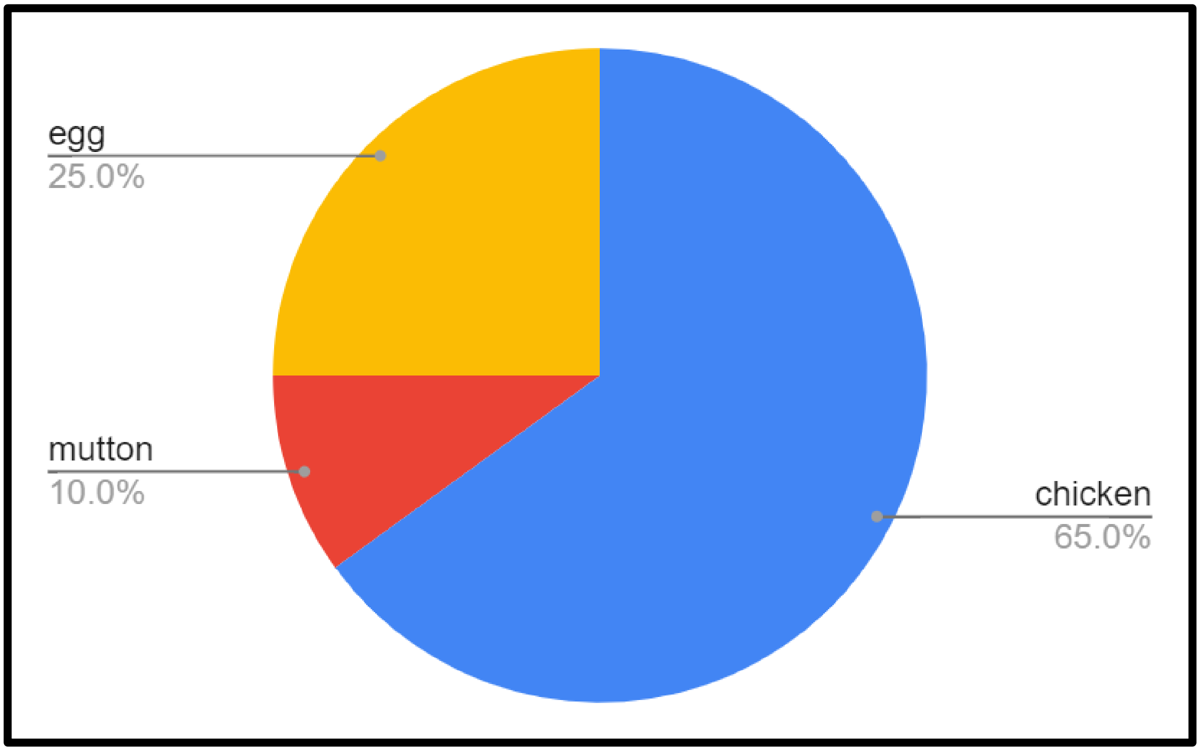


The results of the study revealed that Milk and dairy products like paneer and cheese are consumed by most of the participants, therefore, contributing to the highest carbon emission compared to the other dairy products.

According to a study by Shakhbulatov et al., 2019, The carbon footprint of dairy products like milk, paneer, and cheese depends on the production process and the source of the ingredients. Generally, dairy products have a high carbon footprint due to the energy-intensive production process and the emissions from cows. The carbon footprint of milk is estimated to be around 1.2 kg of CO2e per liter, while paneer and cheese have a higher carbon footprint due to their higher fat content. Additionally, the carbon footprint of dairy products can vary depending on the source of the ingredients, such as whether the milk is sourced from grass-fed cows or grain-fed cows.

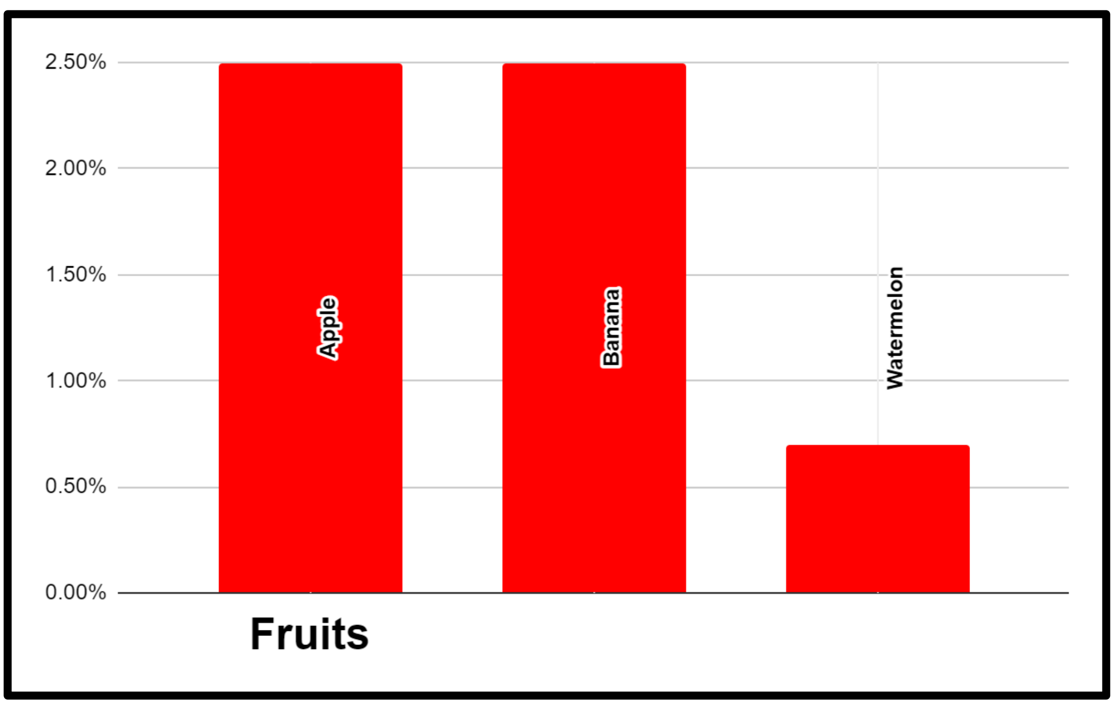
The production of milk has detrimental effects on the environment, including the release of greenhouse gasses and the nutrient enrichment of aquatic bodies (Muthu, 2019). The dairy business uses energy in a variety of ways to produce different dairy products. According to Todde et al. (2018), as the dairy business becomes more energy-intensive, the economic and environmental costs rise. The price of milk and milk-based products has recently gone up due to the rising cost of raw ingredients and the high energy required for milk processing (Prabhakar et al., 2015). The dairy industry uses a lot of energy in the manufacturing, processing, and storage of various products (Marjan et al., 2009).

Figure 4.5 (4) Comparing the contribution egg and meat to total carbon emissions



The results represent the carbon emission in meat and egg where the consumption of chicken by participants was significantly higher as compared to lamb/mutton or eggs. Chicken has comparatively less carbon footprint in the meat category, and beef/pork has the highest. In this study, there were zero participants who consumed beef and pork leading to a relatively less carbon footprint.

Figure 4.5 (5) Comparison of the contribution of individual fruits to overall fruit carbon emissions by consumption



The results indicated that the most consumed fruits among all were apples, bananas, and watermelon, therefore, contributing to the highest carbon emission that is apples (2.5%), bananas (2.5%), and watermelon (0.7%) respectively. According to a study by Vauterin et al., 2021, Fruits and vegetables have a low carbon footprint because they are grown without the use of fossil fuels or other energy-intensive inputs. They are also typically grown locally, reducing the need for transportation and associated emissions. Additionally, fruits and vegetables are often grown organically, which eliminates the use of synthetic fertilizers and pesticides that can contribute to greenhouse gas emissions.

One of the most significant plant-based foods is vegetables, which provide both nutritional and environmental benefits. Vegetable waste is produced in enormous amounts and has the potential to seriously harm the environment. On the other hand, vegetable waste has a wide range of vital components, such as bioactive substances. To lessen the environmental impact of food production, several waste management strategies may be used to decrease waste. The CF examination includes several stages, including determining the importance and location of the examination, identifying the functional system and unit, inventory inspection, life cycle impact calculation, and perhaps Life Cycle Clarification where the sensitivity assessment may be conducted. (Wróbel-Jdrzejewska et al., 2021).

4.6. Comparing Low carbon score recipes with high carbon score:

Table 1:

Recipe Name: Vegetable Jalfrezi	**Recipe name: Mutton jalfrezi**
Ingredients: Vegetables, spices, and tomato sauce	**Ingredients:** Mutton, spices, and tomato sauce
Carbon score: 3.56	**Carbon score: 7.65**

Results indicate that when mutton jalfrezi and vegetable jalfrezi are compared, the vegetable jalfrezi has a lower carbon score. The only difference between the ingredients is that the veggies have been replaced with mutton.

Table 2:

Recipe Name: Grilled chicken skewers	**Recipe name: Grilled beef skewers**
Ingredients: Peppers, mushrooms, and onions, Spices, chicken	**Ingredients:** Peppers, mushrooms, and onions, Spices, chicken
Carbon score: 6.85	**Carbon score: 15.58**

The findings demonstrate a considerable difference between the carbon scores of grilled beef and chicken skewers, with beef skewers scoring higher than chicken skewers.

Table 3:

Recipe Name: Vegetable Salsa	**Recipe name: Chicken Caesar salsa**
Ingredients: Vegetables, spices, black beans, olive oil, cheese	**Ingredients:** Chicken, spices, black beans, olive oil, cheese
Carbon score: 4.66	**Carbon score: 6.56**

The results showed that, of the two dishes examined, the chicken salsa dish had the highest carbon footprint, with a carbon footprint of 6.56. Nevertheless, there isn't much of a distinction between the two carbon footprints. All the meats have an environmental impact, but chicken has the least.

Table 4:

Recipe Name: Vegan Pie	**Recipe name: Lamb pie**
Ingredients: Lentils, chickpeas, mushrooms, celery, spices	**Ingredients:** Lentils, Lamb, mushrooms, celery, spices
Carbon score: 3.05	**Carbon score: 6.85**

The results of the study showed that there is a 3.85 difference between the carbon footprint of vegan pie and lamb pie, which is a considerable difference. The carbon footprint of red meat, such as beef and pork, is the largest on the food chain.

Future of the study:

This is the first study on Indian athletes that utilizes 24-hour diet recall to determine their carbon footprint. This would be the baseline for future calculations of carbon score in athletes. Carbon footprint information can serve as a basis for policymaking and decision-making and can help inform the development of more sustainable food production and consumption practices.

A high-level Food Systems Summit was organized in 2021 by Secretary-General António Guterres to encourage renewed global commitment to resilient and sustainable food systems. The summit was placed to specific emphasis on the role that food systems play in meeting the Sustainable Development Goals (SDGs) and the emission reduction targets of the Paris Agreement by bringing together governments, civic society, and the commercial sector. This will make it possible to create daring cross-sectoral projects that will change the food system.

In order to improve health and lower the risk of chronic diseases, FBDG are promoted in nations all over the world, and new FBDGs that take sustainability into account are emerging in an increasing number of nations as advised by the FAO/WHO. Furthermore, the need for immediate and significant changes in the food system is becoming more widely recognised. According to a report from 2020, not only are changes in food consumption patterns required, but improvements in food production are also essential. To further reduce environmental footprint, production-side initiatives are advocated, such as increasing yield and increasing production efficiency.

The calculations in the current study, where the estimated CF of the current and the modeled diets are based on present-day (and past) CF values based on data of the present production systems, do not take into account the potential effects of these future developments on the CF of the individual food items. Therefore, it is necessary to constantly update the CF of food and food systems (Moberg et al., 2020).

Conclusion:

It was clearly seen that in athletes' food, the highest carbon footprint is from the cereals (31.2%) followed by dairy products (17.9%), meat (10.6), confectioneries (9.4%), vegetables(7.9%), and fruits (5.6%), pulses and nuts (6.6%) sugar(6.5%), and lastly fat(5.1%).

Athletes in India have high carbon emissions associated with cereals and dairy products because of their high-energy dietary needs. Cereals and dairy products are often the staple food in the Indian diet and are used as an important source of energy for athletes. These food sources are highly processed and require large amounts of energy and resources to produce, thus leading to high carbon emissions. Additionally, due to India's large population, athletes often have to buy large amounts of these food sources in order to meet their dietary needs, further contributing to their high carbon emissions.

If an athlete doesn't want to turn vegan, there are still ways to reduce their carbon emissions. They can reduce their consumption of red meat and dairy, which have a high environmental impact. They can also switch to eating more plant-based proteins, such as beans, nuts, and lentils, which have a lower environmental impact. Additionally, they can try to buy local and organic produce, which has a lower carbon footprint than conventionally produced food. Finally, they can reduce their food waste by only buying what they need and composting any food scraps. (Karwacka et al., 2022).

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Abbreviation/Acronym and Full form:

Abbreviation/Acronym	**Full form**
CF	Carbon Footprint
AP	Athletes plate
GHGE	Greenhouse Gas Emission
GWP	Global Warming potential
GWPCH4	Global Warming Potential of Methane
CO2e	Carbon Dioxide Equivalent
HEI	Healthy Eating Index

DF	Diet Composition Factors
LCA	Life Cycle Assessment
IOT	Input Output Table
FCF	Food Composition Factors
EnI	Environmental Impact

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