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Review

A Systematic Review of the Effects of Nutrient Intake in Handball Players on Exercise Performance

Agustin Mora-Fernandez [1], Alejandro Lopez-Moro [1], Luis Javier Chirosa-Rios [2] and Miguel Mariscal-Arcas [1,*]

[1] Department of Nutrition and Food Science, University of Granada, 18071 Granada, Spain
[2] Department of Physical Education and Sport, University of Granada, 18071 Granada, Spain
* Correspondence: mariscal@ugr.es

Abstract: Introduction: Modern handball was introduced as an Olympic sport in 1972 and is played by more than 19 million people worldwide. Beach handball was born as an adaptation of court handball in the 1990s. Both modalities are complex and multifactorial ball games characterised by a fast pace and variable game intensities, as well as the strong influence of tactical concepts, social factors and cognitive aspects. Objective: To analyse the nutritional status of both male and female players to assess whether it is in line with specific and general dietary intake demands. Methodology: A systematic search of databases was carried out using keywords with relevant Boolean operators. Results: A total of 468 studies was identified, of which 44 studies were included: 7 on hydration; 22 studies related to energy, macronutrient and fibre intake; 23 that assessed micronutrients; 4 studies on nutritional knowledge and information sources; and 2 articles on eating disorders. A further 85 articles were included in order to cross-check results. Discussion: The need for a state of euhydration and normal plasma electrolyte levels is clear. Adequate energy intake is the cornerstone of the handball athlete's diet to support optimal body function. The ACSM sets daily recommendations of 6–10 g CHO/kg body weight for handball, and daily protein recommendations range from 1.2 to 2.0 g PRO/kg/day and 14 g dietary fibre per 1000 kcal. Conclusion: The nutritional habits of handball players do not seem to be adequate to the demands of the sport, although these demands are not clarified. The inclusion of nutrition professionals could be a key element in the performance of these athletes.

Keywords: handball; beach handball; exercise performance; nutrition

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1. Introduction

Modern handball is a team sport originating in Scandinavia in the early 19th century and was introduced as an Olympic sport in 1972 with the men's discipline and 4 years later at the Olympic Games in Montreal (Canada) with the women's discipline. It is considered one of the most popular team sports in Europe, played by more than 19 million people worldwide [1].

Beach handball was born as an adaptation of court handball in the 1990s on the beaches of Italy and it is a modality that is nowadays consecrated by international bodies with championships in all parts of the world. This discipline has an origin closely linked to court handball, both modalities being complex and multifactorial ball games characterised by a fast pace and variable game intensities, as well as a strong influence of tactical concepts, social factors and cognitive aspects [2,3]. Despite this, there are clear differences in tactics, regulations and the environment in which they are practised, and these differences in the cycles and phases of the game must be understood in order to understand each discipline properly [4,5]. Therefore, although many of the actions performed in both disciplines are similar and are characteristic of high intensity contact sports such as blocking, passing, jumping, short distance running, etc., [6], they are different sports with different demands, court handball being a more physically demanding discipline than beach handball due to the size of the court, the surface and the number of players [7]. Common factors such as nutrition, illness and injury, as well as external influences and environmental conditions can significantly influence sporting performance in both disciplines [2]. Therefore, it is becoming increasingly important to adjust the nutritional intake of handball athletes to try to meet their individual needs to cope with training and competition [8–10].

However, knowledge of specific nutritional strategies during training and competition does not seem to be as clear in handball players. Similarly, energy, macronutrient and micronutrient requirements as well as hydration protocols are not clearly understood according to the physical demands and locomotor power production in handball athletes [11].

Therefore, analysing the current lack of information linking food science and sports nutrition to the sport of handball, as well as the important role that an adequate total nutritional status (hydration, macronutrients, micronutrients, relationship with food and eating disorders, etc.) plays in the sports performance of different sports disciplines, it is clear that there is a need to study the habits, the needs/requirements and the different nutritional problems existing in handball athletes. For this reason, the objective of this systematic review is to analyse the nutritional status of beach and court handball athletes, both male and female, of any age range, level and category, to assess whether this is in accordance with the specific and general demands of sport in terms of fluid intake, energy, macronutrients and micronutrients, as well as whether there is a need to incorporate more professional work on sports nutrition in this population group.

2. Materials and Methods

This review was carried out following the recommendations and criteria set out in the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) and was also registered in PROSPERO [12]. Risk of bias assessment was performed using the blinded Cochrane risk of bias tool.

2.1. Search Strategy

A systematic search was conducted manually by the authors. The databases used for the search were the following: PubMed/MEDLINE, Web of Science (including the entire Web of Science Core Collection: Citation Indexes), Google Scholar and SPORTDiscus. The search syntax included the following keywords with relevant Boolean operators inserted in English and their respective translations into Spanish (authors' main languages): ("handball" OR "beach handball") AND ("nutrition" OR "diet" OR "food" OR "nourishment" OR "food intake" OR "eating" OR "macronutrients" OR "carbohydrates" OR "fats" OR "proteins" OR "micronutrients" OR "vitamins" OR "minerals" OR "fibre" OR "fibre diet"). The reference lists about included studies were searched in order to try to avoid any possible omissions with the keyword "only search". The search started on 29 June 2022 and ended on 19 July 2022, the time at which all references were located in the aforementioned databases.

Subsequent bibliographic searches were carried out in Google Scholar and PubMed to contrast the data obtained in handball players with nutritional recommendations or data from high-level sports nutrition bodies or extracted from studies carried out in similar sports disciplines, as well as non-nutritional studies of interest in samples of handball athletes linked to specific aspects of sports performance in the sport in question. These studies were included to try to evidence the data from the main search section by section during the writing of the paper.

2.2. Inclusion and Exclusion Criteria

The main bibliographic review was focused on publications or studies that focused their sample on handball or beach handball athletes, either on their own or together with athletes from other sports disciplines, and also to carry out an assessment of any aspect related to nutrition or diet in this group of athletes. The PICO system was used for the formulation of the questions (P: Beach and court handball athletes of any level, age, category and gender; I: Dietary habits; C: Specific recommendations and demands of the sport of handball and team or intervallic sports with high intensity actions; O: Improvement of sport performance). The small number of publications on this topic finally led us to take as inclusion criteria those papers published between 1989 and 2022. Only narrative journalistic articles of little relevance and those academic publications where findings of interest could not be extracted that were not influenced by the use of different supplements were excluded from this review, placing the focus of the review on whole foods and meals whenever possible, under the term "food first" [13,14]. No omissions were made by gender, age or type of handball played by the participants, or taking into account other aspects such as language, study objective, year and impact of the publication given the sample size and the absence to our knowledge of a previous review on the subject to date.

In order to be able to answer our research question, in the post-research searches we included articles that allowed us to evaluate and compare the different nutritional data extracted in handball athletes with the possible demands that these athletes may present. In the absence of specific recommendations by important institutions in sports nutrition, we tried to contrast the data with studies on sports with similar characteristics to handball (e.g., intervallic team sports with high intensity actions, game conditions, etc.). Only articles whose data did not allow us to discuss the data obtained in the sport of handball and to draw valid conclusions were excluded from these searches. Therefore, a special focus was placed on using review papers from leading researchers or institutions in the field of sports nutrition.

2.3. Data Mining and Synthesis Methods

The following data were extracted from the included studies: authors and year of publication, characteristics of the sample (age, category, sex, level of competition, country, etc.), sport modality (court handball or beach handball), design of the study (parameters to be measured, tools or methods used for this purpose, time period of the study, etc.), main findings (nutritional knowledge, analysis of water, energy and macronutrient and micronutrient intake, prevalence of behavioural disorders or diseases associated with nutritional aspects, etc.), main findings (nutritional knowledge, analysis of water, energy, macronutrient and micronutrient intake, prevalence of behavioural disorders or diseases associated with nutritional aspects, etc.) and whether the data are specified by playing positions. The studies were grouped according to their study design and objective, independently of discipline, sample characteristics and year of publication and ordered in alphabetical order of the first authors' surnames.

No methodological assessment of the studies was carried out given the need for this review to include the maximum possible sample size in accordance with the objectives of the review.

Only studies focusing on any nutritional aspect with samples of handball athletes in their different sports modalities were included in the results. The rest of the studies located in subsequent external searches were included in other sections of this review due to the interest they presented when comparing these data with those of the main search of the study.

3. Results

3.1. Search Results

Concerning the main bibliographic search, a total of 468 studies was identified in the initial search of the different databases. Fifty studies were screened, eliminating 418 studies based on their titles and/or abstracts and omitting duplicate articles. It was decided to exclude a further nine studies due to their lack of interest in the subject matter of this systematic review. The full text versions of the remaining 41 articles were assessed for eligibility. Three studies associated with two assessed review articles were included [15–17]. Finally, we selected a total of 44 articles available for inclusion in the review as shown in the flow chart (Figure 1).

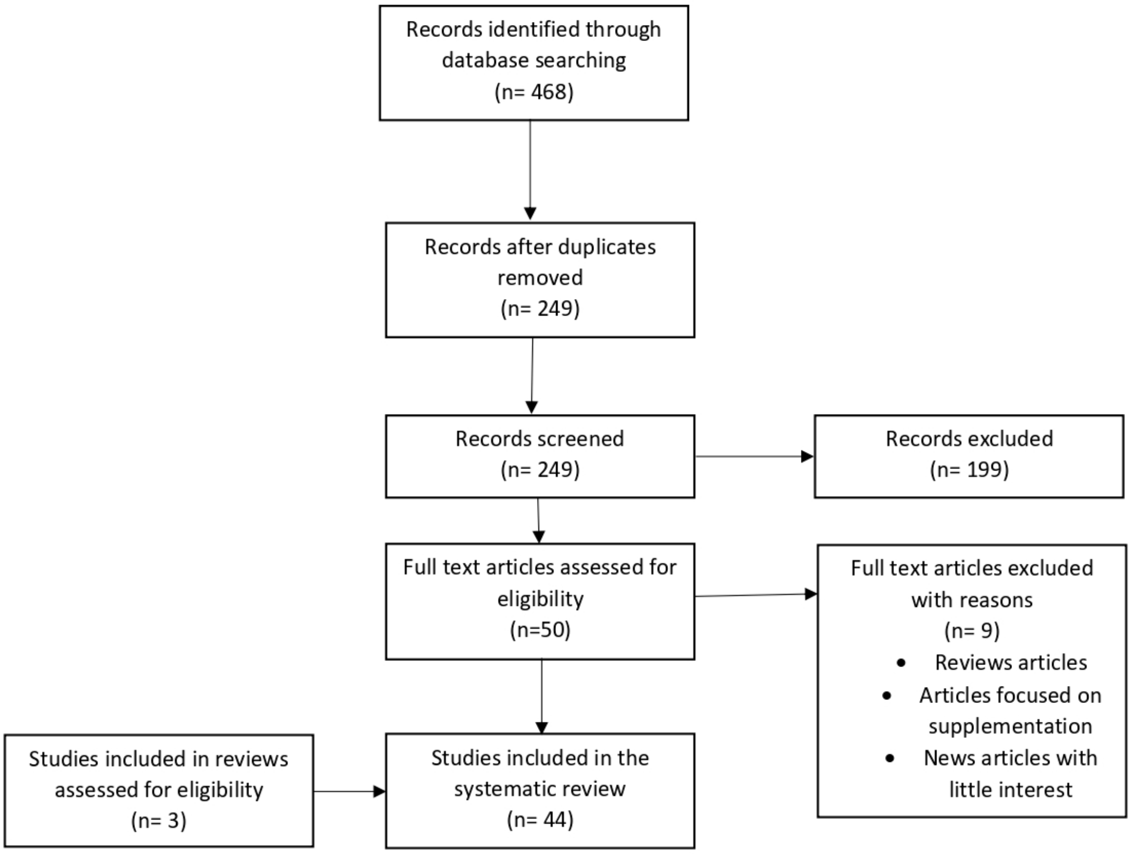

Figure 1. Study retrieval process flowchart.

3.2. Characteristics of the Studies

A summary of the characteristics of the studies linking nutritional aspects in samples of handball athletes is included according to the variables analysed in Tables 1–4. Seven studies were related to hydration in handball athletes, five of them with hydration habits and water/liquid intake throughout the day or at times close to training or matches [18–22] and another two with water and electrolyte demands during training and competition [23,24]. Twenty-two studies were related to the intake of energy, macronutrients and fibre in samples with handball players present; 20 of them referred to the mean energy, carbohydrate, fat, protein and/or fibre intake of these athletes in different phases of the season [18,19,22,25–41], with only one of them making specifications by playing position [35], while five focused on analysing the energy and different macronutrient demands [22,37,42–44]. In addition, 13 other studies analysed, together or not, energy, fibre or nutrient intake; dietary habits and consumption of different food groups in different handball athletes [19,26–28,34,36,39,40,45–49]; as well as the effects of a nutrition education programme on dietary habits and consumption of different foods in one of them [28]. Twenty-three studies evaluated micronutrient status in handball athletes, 17 articles analysing the nutritional intake of athletes [18,22,25,26,28–33,35,36,45,50–53], and 14 in conjunction or not with different biochemical analyses in samples of interest [22,29,31–33,45,50,53–59]. Finally, four studies provided information on the nutritional knowledge and main sources of information of handball athletes [21,40,46,49], and two additional articles on eating disorders in these athletes [60,61]. In those studies, dealing with interventions or presenting samples using dietary supplements [41,50,53,59], only data excluding or prior to the use of supplements were included.

Table 1. Evaluation of hydration, water intake and water demand.

Authors and Year	Sample (Age, Composition, Level of Competition and Gender)	Design Study and Tools	Major Findings
Aguiar et al. 2011 [18]	N = 26 (7 elite Portuguese men track players; 20.1 ± 4.9 years old; 81.9 ± 8.9 kg; 190.2 ± 7.9 cm; 69.36 ± 6.89 kg FFM; 11.87 ± 3.30 kg FM)	R 24 h 7 days + strength test	Average water intake (g): 2346 ± 1149
Cunniffe et al. 2015 [23]	N = 17 female UK international team track players (26 ± 5 years old; 1.72 ± 0.06 m; 70.7 ± 8.5 kg)	HR, fluid balance and electrolyte content in a 6-day tournament.	HR: 155 ± 14 bpm. SR: 1.02 ± 0.07 L/h Mean concentration of sodium in sweat: 38 ± 10 mmol/L
De Sousa et al. 2008 [19]	N = 326 Brazilian athletes from official sports federations 11–14 years old (122 women + 204 men) of sports and handball track	R 24 h of 4 days + anthropometry	4.6% ingested more fluids than IA More adequacy in women' intake
Ferigollo et al. 2012 [24]	N = 7 Brazilian male track handball players from the State of Santa Catarina (19–45 years old; 11.9 ± 0.7% FM)	BIA + questionnaire + calculation SR	71 ± 0.65% mean total body water according to BIA. SR mean= 6.1 ± 1.5 mL/min <1% lost weight
Leal et al. 2018 [20]	N = 19 Brazilian adolescents of track of infantile category and cadet of 12–15 years old of the club of the City of Sao Pablo	Questionnaire of 11 questions + Bristol scale	68.4% athletes with a habit of 200–800 mL during + 250–500 mL rest of the day. Most with evacuation once a day)
Musaiger et al. 1994 [21]	N = 304 (75 Bahrain top-flight track handball athletes; ≤20 years old = 24 + ≥21 = 51)	Interview with questionnaires by nutritionist	54% drank water, 31% fruit juice + water, 8.6% tea + water, 3.9% oranges + water, and 3% nothing
Nigan et al. 2013 [22]	N = 22 female track handball athletes of the Benin national team. EG = 16 (23.81 ± 4.02 years old; 167.31 ± 4.93 cm; 60.56 ± 4.6 kg) and CG = 6 (22.83 ± 3.26 years; 169.67 ± 4.03 cm; 74.08 ± 8.73 kg)	Blood analysis + EE by pedometer + calorimetric bomb and weighing	1.38 ± 0.64 L in EG and 0.76 ± 0.38 L in CG. Lost weight 0.19 ± 2.03 kg in EG and 0.2 ± 1.68 kg in CG

Table 2. Intake and requirements of energy, macronutrients and fibre. Frequency of consumption by food groups.

Authors and Year	Sample (Age, Composition, Level of Competition and Gender)	Design Study and Tools	Major Findings
Aguiar et al. 2011 [18]	N = 26 (7 elite Portuguese men track players; 20.1 ± 4.9 years old; 81.9 ± 8.9 kg; 190.2 ± 7.9 cm; 69.36 ± 6.89 kg FFM; 11.87 ± 3.30 kg FM)	R 24 h 7 days + strength test	Energy (kJ/day): 11,109 ± 3437 (2654 ± 821 kcal/day); CHO (g): 331 ± 123; PRO (g): 121 ± 32; FAT (g): 88 ± 34
Caprio et al. 2018 [25]	N = 12 Brazilian junior men's players (18–21 years old; 79.52 ± 10.77 kg; 14.23 ± 4.65 kg FM; 65.33 ± 6.99 kg FFM)	3 days of R 24 h	Energy (kcal/day): 1956 ± 98,1; CHO (%): 52.83 ± 13.01; FAT (%): 30.52 ± 10; PRO (g/kg/day): 1.44 ± 0.68. Fibre (g): 41.74 ± 22.03
De Sousa et al. 2008 [19]	N = 326 Brazilian athletes from official sports federations 11–14 years old (122 women + 204 men) of sports and handball track	R 24 h of 4 days + anthropometry	High consumption of foods of low nutritional quality and high energy density PRO Above ACSM recommendations Women low CHO/kg weight
Dymkowska-Malesa et al. 2016 [26]	Women's track team Energa AZS Koszalin from Polish Super League (22–36 years old; 67 kg; 173 cm)	Questionnaires + R 24 h for 7 days	46% an intake 2–3 h before and 56% in 1 h post Energy, CHO, PRO and FAT 90.3%, 99.6%, 96.3% and 109.5%, respectively
Ersoy 1995 [29]	10 Turkish elite female track handball athletes (19–25 years old; 52–79 kg; 160–185 cm; 19.6–23 kg/m^2)	3-day record	Energy (kcal): 1756; PRO (g): 51.1; CHO (g): 229; FAT (g): 68.1; Fibre (g): 4.1
Fuchs et al. 2021 [42]	N = 11 track handball athletes from 1st, 2nd and 3rd Norwegian league (6 male + 5 female) aged 25 ± 8 years old; 1.75 ± 0.09 m; 76.7 ± 9.4 kg	Portable spiro-ergometry + local position measurement	Good applicability of the method in handball
Guerra et al. 2006 [45]	N = 14 junior female players of Brazilian championship track team (12–14 years old; 20.28 ± 2.19 kg/m^2)	Blood test + questionnaire and FFQ	Majority consumption of: Bread (85.7%); 64.3% daily juice; 7.1% rejection of salads; 57.1% fat source margarine; 42.9% soft drinks every day
Janiszewska et al. 2012 [27]	N = 15 Polish male track players (23.0 ± 3.3 years old; 75.5 ± 4.8 kg; 183.3 ± 5.3 cm; 8.6 ± 1.0% FM; 69.0 ± 4.1 kg FFM)	Qualitative questionnaires	Two players good in fibre and fat intake. Raw vegetables source of fibre. Margarine and butter as sources of fat
Jesus et al. 2022 [43]	N = 88 athletes (19.1 ± 4,2 years old, 21.8 ± 2.0 kg/m^2, 27% women). 7 Portuguese track handball athletes	DLW + FFM (4 compartments)	EA increased by 14.8 kcal/kg FFM (2.9 mean). Clinically low EA in preparatory phase in 11 athletes
Leme et al. 2009 [30]	N = 11 Brazilian teenage female court players from a São Paulo club (14.9 ± 0.8 years old, 166 ± 8.5 cm; 67.8 ± 15.7 kg; 24.5 ± 3.7 kg/m^2)	Anthropometric measurements + R 24 h	Energy: 1964 kcal/day; CHO (g): 266; FAT (g): 65; PRO (g): 80
Martin et al. 2015 [46]	N = 57 athletes (10–16 years old) of a Romanian Olympic track handball club	FFQ + sport test	85% they had breakfast, 73% snack 1, 98% lunch, 66.1% snack 2 and 87.5% dinner Higher intake of simple sugars in snacks

Table 2. *Cont.*

Authors and Year	Sample (Age, Composition, Level of Competition and Gender)	Design Study and Tools	Major Findings
Martínez-Rodríguez et al. 2021 [47]	N = 59 Spanish beach team athletes; 38 men: 14 juniors (17.0 ± 0.1 years, 176.9 ± 6.7 cm and 70.1 ± 11.2 kg) and 24 seniors (25.5 ± 4.7 years, 183.0 ± 6.4 cm and 81.3 ± 7.6 kg); 21 women: 7 juniors (16.1 ± 1.46 years old; 165.0 ± 9.9 cm and 56.3 ± 8.7 kg) and 14 seniors (23.2 ± 2.9 years old, 166.0 ± 6.3 cm and 63.7 ± 8.9 kg)	KIDMED + BIA + HGS and CMJ	76% women and 66% men adherence to MD 9.5% of women and 20% of men with ↓ adherence. Significant negative relationship between adherence to MD and body weight and HGS
Molina-López et al. 2013 [28]	N = 14 Spanish DHB men's track players (22.9 ± 2.7 years old; 1.87 ± 0.06 cm; 86.72 ± 5.36 kg; 11.58 ± 2.53% FM)	R 72 h + FFQ + anthropometry 4 months of a nutritional program	Energy and CHO below & FAT above recommendations Significant program increases in energy and macros
Musaiger et al. 1994 [21]	N = 304 (75 Bahrain top-flight track handball athletes; ≤20 years old= 24 + ≥21 = 51)	Interview with questionnaires by nutritionist	28% ate breakfast daily (33.3% omitted). Rice (80%) most consumed food pre. Average time: 3.1 h between ingestion and event
Nigan et al. 2013 [22]	N = 22 female track handball athletes of the Benin national team. EG = 16 (23.81 ± 4.02 years old; 167.31 ± 4.93 cm; 60.56 ± 4.6 kg) and CG = 6 (22.83 ± 3.26 years old; 169.67 ± 4.03 cm; 74.08 ± 8.73 kg)	Blood analysis before & after a match + EE by pedometer + calorimetric bomb and weighing	EE (kcal) of EG vs. CG: 439.17 ± 142.81 (3062.7 ± 746.3 m travelled) vs. 174.78 ± 46.96 (1763 ± 311.4 m travelled)
Nuviala et al. 1995 and 1999 [31,32]	N = 20 female handball players from the national and international competition court in Spain (19.9 ± 3.6 years old; 62.3 ± 7.8 kg; 164.3 ± 4.3 cm)	7-day dietary survey + haematological and urine analysis	Energy intake in handball (kcal): 2284.6 ± 547.6
Rokitzki et al. 1994 [33]	N = 62 athletes + 16 non-athletes; 12 regional German court handball players (23.8 ± 7.9 years old; 64.3 ± 11.6 kg; 167.3 ± 13.5 cm)	Blood samples + urine measurements after dietary diary	TEI (kJ/day) in handball: 9498 ± 256; CHO (g) in handball: 232 ± 96 (45% TEI)
Rusu et al. 2016 [34]	N = 15 Romanian male athletes of junior category I track handball team	Food questionnaires and records + anthropometry + biochemical analysis	EI mean: 4330.14 ± 340.69 kcal/day (13.46% PRO, 34.3% FAT and 52.24% CHO). Vegetable fats 50.11%
Ryszard et al. 2012 [48]	N = 50 (35 Polish female court handball players (20.7 ± 2.2 years old; 66.2 ± 6.8 weight; 22.4 ± 1.8 kg/m^2)	Weight and oestradiol at the beginning and end of the preseason	No relationship was observed between eating habits and nutritional status with oestradiol concentrations
Sá et al. 2021 [35]	N = 64 Portuguese track handball athletes under 16/18 elite; 31 female (14.8 ± 0.9 years old; 63.9 ± 10.0 kg; 1.6 ± 0.1 m); 33 male (16.1 ± 0.5 years old; 77.1 ± 12.1 kg; 1.8 ± 0.1 m)	BIA + FFQ	Higher energy, PRO, FAT intake in men vs. women. Energy and protein intake significantly different between game positions

Table 2. *Cont.*

Authors and Year	Sample (Age, Composition, Level of Competition and Gender)	Design Study and Tools	Major Findings
Silva et al. 2016 [36]	N = 6 players of the Brazilian national beach team (24.7 ± 2 years old; 63.8 ± 7.1 kg; 168 ± 0.08 cm; 24.9 ± 3.0% FM)	Anthropometric + physiological evaluation + nutritional profile	Energy (kcal/day): 2376 ± 659 Excess simple CHO in the diet. High cardiometabolic demand, HR and lactate production
Silva et al. 2017 [44]	N = 57 athletes (39 male + 18 female); 6 Brazilian court handball players from national and international competitions	REE and TEE (IC + DLW); EI (DXA + DWT)	TEE increased by 18.8 ± 8.5%. Positive energy balance: 33.0 ± 52.3 kcal/day. Energy availability: 2674 ± 286 kcal/day
Staskiewicz et al. 2019 [49]	N = 119 athletes (mean age 24.4 years); 30 professional Polish track handball players	FFQ + hedonic scale	Increased wine consumption in handball players. Most fresh fruits 5–6 per week, fresh vegetables 3–4 and 5–6 per week, and vegetable oils 3–4 times/week
Suzuki et al. 2020 [37]	11 female Japanese national team track handball players (26.9 ± 4.9 years old; 66.5 ± 6.4 kg; 170.6 ± 7.1 cm; 17.2 ± 2.7 kg FM; 49.4 ± 4.1 kg ffm)	Urine NBAL technique (day 2–3) + registration by dietician (days 1, 2 and 4) during camp	NBAL 0 in 1.57 g/kg/day
Teraz and Meulenberg 2019 [38]	N = 26 players from the Slovenian semi-professional teams: 17 men (22.1 ± 4.3 years old; 186.8 ± 6.1 cm; 90.4 ± 6.9 kg; 16.2 ± 3.5% FM; 74.9 ± 5.1 kg FFM); 9 women (21.9 ± 2.7 years old; 174.1 ± 7.2 cm; 71.5 ± 7.4 kg; 26.2 ± 4.8% FM; 52.5 ± 3.1 kg FFM)	BIA + 7-day diet diary	100% did not reach recommendations for CHO and 11.1% and 14.3% for PRO days of training and rest, respectively High FAT consumption
Van Erp-Baart et al. 1989 [39]	N = 8 Dutch female elite track players (22 ± 2 years old; 63.2 ± 4.2 kg; 166.0 ± 6.3 cm; 25.0 ± 3.8% FM)	4- or 7-day dietary diary	Energy (kcal): 2151; CHO (g): 215; PRO (g): 76; FAT (g): 101. Bread/cereals and dairy main energy sources in all sports
Waly et al. 2013 [40]	N = 35 Omani male track players for national competition (27 ± 3 years old; 75 ± 10 kg; 166 ± 12 cm)	Interviews on demographics, anthropometry and nutritional practices	51% with lunch as the main meal. Energy (kcal): 3674 ± 265; CHO (g): 596 ± 66. PRO (g): 147 ± 28; FAT (g): 78 ± 20
Wardenaar et al. 2017 [41]	N = 553 athletes; 18 Dutch Olympic elite and sub-elite track handball players (24.1 ± 3.1 years old; 176.6 ± 4.4 cm; 70.7 ± 5.3 kg)	3–4 R 24 h	CHO (g/kg): 3.1 ± 0.4; PRO (g/kg): 1.3 ± 0.3

Table 3. Status and intake of micronutrients (vitamins and minerals) and associated biochemical analyses.

Authors and Year	Sample (Age, Composition, Level of Competition and Gender)	Design Study and Tools	Major Findings
Aguiar et al. 2011 [18]	N = 26 (7 elite Portuguese men's track players; 20.1 ± 4.9 years old; 81.9 ± 8.9 kg; 190.2 ± 7.9 cm; 69.36 ± 6.89 kg FFM; 11.87 ± 3.30 kg FM)	7 days R 24 h + strength test	Ca (mg) 93 ± 353; Mg (mg) 244.7 ± 78.8 8 (under recommendations)
Bauer et al. 2018 [50]	N = 70 German 1st division male Caucasian athletes of various nationalities (26.3 ± 4.9 years old; 192.5 ± 6.3 cm; 96.7 ± 9.2 kg)	Blood extraction + questionnaires	Vit. D: 33.5 ± 10.9 ng/mL (8.4–70.7 ng/mL). 44.3% inadequacy (<30 ng/mL) and 7% with deficiency (<20 ng/mL)
Bauer et al. 2019 [54]	N= 50 Caucasian male 1st division athletes of various nationalities (25.7 ± 5 years old; 191.2 ± 6.4 cm; 94.8 ± 8.9 kg)	Blood extraction + cycle ergometer test + vascular function measurements	82% sufficient levels of 25-OH vit. D (≥30 ng/mL) and 18% below. Higher central and systolic blood pressure in athletes with adequacy
Caprio et al. 2018 [25]	N = 12 junior male players from Brazil (18–21 years old; 79.52 ± 10.77 kg; 14.23 ± 4.65 kg FM; 65.33 ± 6.99 kg FFM)	3 days R 24 h	ICa (mg): 390.40 ± 180.80 (Below DRI)
Dymkowska-Malesa et al. 2016 [26]	Women's track team Energa AZS Koszalin from Polish Super League (22–36 years old; 67 kg; 173 cm)	Questionnaires + R 24 h for 7 days	Insufficient Ca (89.7%), Fe (80.2%) and K (76%). Excessive Mg (132.5%), P (232.7%), Zn (1656.1%), Na (180.5%), vit. A (161.9%), B1 (118.2%), B2 (182.7%), B6 (168.5%), C (233.8%) and E (194.3%)
Ersoy 1995 [29]	N = 10 elite female track handball athletes from Turkey (19–25 years old; 52–79 kg; 160–185 cm; 19.6–23 kg/m^2)	3-day record	Two with anaemia and 2 with low levels of serum ferritin and transferrin saturation. Ca (mg): 603; Fe (mg): 11.4; Vit. A (IU): 6290; B1 (mg): 0.99; B2 (mg): 0.88; niacin (mg): 6.9; vit. C (mg): 105
García Dávila et al. 2015 [51]	N = 14 male track players from the UANL team in Mexico (22.3 ± 1.83 years old; 84 ± 14 kg; 180 ± 0.66 cm; 64.5 ± 7.8 kg FFM; 15.4 ± 9 kg FM)	Training sessions + R 24 h for 3 days	Excessive intake with significant differences in vit. B1, B2, C, E, P, K, Fe and Se ($p < 0.01$) and in B3, B6, B12, A, D, Ca and Zn ($p < 0.05$)
Guerra et al. 2006 [45]	N = 14 junior female players of the Brazilian championship track team (12–14 years old; 20.28 ± 2.19 kg/m^2)	Blood test + questionnaire and FFQ	14.29% with anaemia (Hb < 12.0 g/dL). Mean Hb (g/dL): 12.7 ± 0.9. Low consumption of foods with Ca

Table 3. *Cont.*

Authors and Year	Sample (Age, Composition, Level of Competition and Gender)	Design Study and Tools	Major Findings
Krahenbühl et al. 2018 [52]	N = 68 adolescent female Brazilian athletes from national and regional competition track. HG (14.43 ± 1.3 years old; 59.12 ± 7.8 kg; 161.39 ± 5.3 cm) and CG (14.69 ± 1.9 years olds; 54.68 ± 10.8 kg; 160.62 ± 7.1 cm)	DEXA and anthropometry + Ca intake, vit. D and sun exposure questionnaire	Similar sun exposure, Ca and vit. D in CG vs. HG. Higher BMC and BMD in HG
Krzywanski et al. 2016 [55]	N = 409 Polish athletes of international level (228 men and 181 women Caucasian skin type I–III)	Group blood samples every 3 months	84.4% inadequate in winter, 77.6% spring, 57.1% summer and 79.6% autumn indoors Higher in outdoor vs. indoor sports
Leme et al. 2019 [30]	N = 88 athletes (19.1 ± 4.2 years old, 21.8 ± 2.0 kg/m^2, 27% women); 7 Portuguese track handball athletes	DLW + FFM (4 compartments)	Ca (mg): 1053; Fe (mg): 12; vit. C (mg): 115
Malczewska-Lenczowska et al. 2017 [56]	N = 224 young Polish female athletes (16.9 ± 1.8 years old; 61.7 ± 9.3 kg; 170.7 ± 7.5 cm); 24 handball track athletes	Blood tests in 3 groups: stages I, II and III	45% in stage I and 15% in stage II. No case of anaemia
Molina J et al. 2010 [53]	N = 16 professional track handball players from Spain (22.9 + 2.7 years old; 87.3 ± 5.1 kg; 187 ± 5 cm; 11.8 ± 2.4% FM)	R72h + anthropometry + blood sample pre, post and post + 2 months supplementation	Vit. B12 and folic acid before: 15.40 ± 14.53 µg/d and 301.97 ± 89.05 µg/d. 50% and 7.1% deficient in folic acid and vit. B12
Molina-López et al. 2013 [28]	N = 14 Spanish DHB men's track players (22.9 ± 2.7 years old; 1.87 ± 0.06 cm; 86.72 ± 5.36 kg; 11.58 ± 2.53% FM)	R72h+ FFQ + anthropometry + 4 months of a nutritional program	No significant changes, except vit. B12 at week 8 and vit. D and E at week 16 vs. week 0.
Nigan et al. 2013 [22]	N = 22 female track handball athletes from the Benin national team EG = 16 (23.81 ± 4.02 years old; 167.31 ± 4.93 cm; 60.56 ± 4.6 kg) and CG = 6 (22.83 ± 3.26 years old; 169.67 ± 4.03 cm; 74.08 ± 8.73 kg)	Blood analysis before & after a match + EE by pedometer + calorimetric bomb and weighing	Fe (mg/day): 65.89 ± 1.64 GA vs. 65.99 ± 1.21 CG. Vit. C (mg/day): 42.98 ± 1.90 EG vs. 43.6 ± 1.92 CG. Reduction plasma albumin, increase RBC in EG. Decline serum Fe, serum transferrin, and Fe-binding capacity
Nuviala et al. 1995 [31]	N = 166: 20 handball players on the national and international competition track in Spain (19.9 ± 3.6 years old; 62.3 ± 7.8 kg; 164.3 ± 4.3 cm)	7-day dietary survey + haematological analysis	Fe: 12.9 ± 2.7 mg/day 35% Fe deficiency and 5% iron deficiency anaemia

Table 3. *Cont.*

Authors and Year	Sample (Age, Composition, Level of Competition and Gender)	Design Study and Tools	Major Findings
Nuviala et al. 1999 [32]	N = 143: 20 handball players on the national and international competition track in Spain (19.9 ± 3.6 years old; 62.3 ± 7.8 kg; 164.3 ± 4.3 cm)	7-day dietary survey + urine and blood analysis	75% Mg and Zn below DRI, and 65% below safe daily intake of Cu (1.5 mg/day).
Ponorac et al. 2020 [57]	N= 152 participants. N = 24 top national level track handball athletes from Bosnia and Herzegovina (20.8 ± 1.7 years old; IMC= 23.0 ± 2.3 kg/m^2)	Blood tests and evaluation in 3 categories: stages I, II and III	Higher prevalence (27.1%) of stage II in athletes vs. non-athletes; bm values: Hb 133.0 ± 11.7 g/L; ferritin 28.5 ± 18.5 µg/L; transferrin saturation 19.4 ± 14.2%
Rokitzki et al. 1994 [33]	N = 62 athletes + 16 non-athletes; 12 regional German court handball players (23.8 ± 7.9 years old; 64.3 ± 11.6 kg; 167.3 ± 13.5 cm)	Blood samples + urine measurements after dietary diary	B2 in bm: 1.4 ± 0.5 mg/day. 353 ± 74 nmol/L vit. B2 in blood in bm. Alpha-EGR mean in bm of 1.32 ± 0.18
Sá et al. 2021 [35]	N = 64 elite Portuguese track handball athletes under 16/18; 31 females (14.8 ± 0.9 years old; 63.9 ± 10.0 kg; 1.6 ± 0.1 m); 33 males (16.1 ± 0.5 years old; 77.1 ± 12.1 kg; 1.8 ± 0.1 m)	BIA + FFQ	Vit. E, thiamine, folate, Mg, Ca, Zn and Fe significantly higher in men vs. women
Sacirovic et al. 2013 [58]	N = 134 female athletes from different sports from Bosnia and Herzegovina (41 aged 10 ± 3.2 years old; 42 junior aged 15 ± 2.1 years old; and 51 senior aged 23 ± 5.7 years old)	Laboratory tests and blood tests in 3 years (2010, 2011 and 2012)	Lower number of erythrocytes in 2010 and 2011. Hb significantly different in 2010 and 2011 to reference values Serum Fe lower in 2010 and 2011.
Silva et al. 2016 [36]	N = 6 players of the Brazilian national beach team (24.7 ± 2 years old; 63.8 ± 7.1 kg; 168 ± 0.08 cm; 24.9 ± 3.0% FM)	Anthropometric + physiological evaluation + nutritional profile	Vit. E (6.9 ± 2.2 mg), vit. C (117.4 ± 44.6 mg), Ca (717.1 ± 326.04 mg), Zn (10.3 ± 2.75 mg) and Fe (12.2 ± 4.4 mg)
Valtueña et al. 2021 [59]	N = 95 male players (27.3 ± 4.6 years old; 82.5 ± 12.4 kg; 184.7 ± 11.1 cm) from 6 sports modalities; 17 elite track handball players from Spain	Blood samples in 3 moments of the season + vit. D supplementation protocol	Higher levels in Caucasian players, outdoor and fall sports Annual mean levels of bm: 93.7 ± 24.0 nmol/L

Table 4. Knowledge about sports nutrition and prevalence of eating disorders.

Authors and Year	Sample (Age, Composition, Level of Competition and Gender)	Design Study and Tools	Major Findings
Baldó Vela et al. 2021 [60]	N = 124 male athletes from major clubs of Spanish national federations of various sports (21–30 years old, 73–90 kg, 176.2–187 cm and 10–19.7% FM)	Questionnaires CHAD + EAT-40 + EDI-2 + BSQ	18.5% with possible ED, without significant differences between groups
Martin et al. 2015 [46]	N = 57 athletes (10–16 years old) from the Romanian Olympic track handball club	FFQ + sport test	Nutritional knowledge related to effort parameters and body weight
Martínez-Rodríguez et al. 2012 [61]	N = 69 athletes from the Spanish national beach handball team: 36 men (18 juniors aged 16.7 ± 0.46 years old, 181 ± 5.9 cm and 78.1 ± 12.2 kg; and 18 seniors aged 25.0 ± 5.19 years old, 188 ± 7.73 cm and 90.1 ± 13.4 kg); 33 women (18 juniors aged 16.7 ± 0.59 years old, 167 ± 4.9 cm and 62.4 ± 7.29 kg; and 15 seniors aged 24.8 ± 4.71 years old, 169 ± 5.31 cm and 64.9 ± 7.87 kg)	EAT-26 questionnaire to determine ED risk	11% of women and 3% of men with high risk of ED, without differences between categories and sexes. Significant relationship between BMI, weight, height, age
Musaiger et al. 1994 [21]	N = 304 (75 top-flight track handball athletes from Bahrain; ≤20 years old = 24 + ≥21 = 51)	Interview with questionnaires by nutritionist	TV, radio and magazines (56.8%); coaches (17.4%) and other players (9.4%) as main sources of info
Staskiewicz et al. 2019 [49]	N = 119 athletes (mean age 24.4 years old): 30 professional Polish court handball players	FFQ + hedonic scale	16 athletes with an unsatisfactory level, 13 with a sufficient level and 1 with a good level of nutritional knowledge. Majority 18–23 years old with insufficient nutritional knowledge
Waly et al. 2013 [40]	N = 35 Omani male track players for national competition (27 ± 3 years old; 75 ± 10 kg; 166 ± 12 cm)	Interviews on demographics, anthropometry and nutritional practices	23% with good knowledge about energy intake, 63% PRO, 46% CHO, 11% FAT. Coaches (54%), sports magazines (26%), colleagues (11%) and television (9%) main sources of information

Of these, only three studies included a sample of beach handball athletes [36,47,61]. In addition, the great majority of them presented samples of athletes with mean age over 18 years or the senior category [18,21–29,31–33,36–43,48–51,53,54,57,59,60]. In relation to the sex of the athletes, 13 studies included in their sample only male handball athletes [18,24,25,27,28,34,40,50,51,53,54,59,60], 19 did so with female samples [20,22,23,26,29–33,36,37,39,41,45,48,52,56–58], 9 dealt with mixed samples including both sexes [19,35,38,42–44,47,55,61] and 3 other articles did not specify the sex of the sample used [21,46,49]. In relation to the level of the athletes, the results obtained from the different studies showed a wide variability.

4. Discussion

4.1. Hydration

The need for a state of euhydration and normal plasma electrolyte levels during sport is clear because of its influence on exercise performance and the development of fatigue [62,63]. Fluid replacement guidelines before, during and after exercise are necessary to promote this state of euhydration in the athlete. Before exercise, there is no universal agreement on optimal hydration status. Slow intakes of 5–7 mL/kg of sodium-containing beverages (20–50 mEq/L) and/or salt-containing foods or meals at least 4 h before may be appropriate to start physical activity euhydrated and with adequate plasma electrolyte levels [63]. Analysing the colour or frequency of the athlete's urine may be a practical tool to determine if previous hydration practices are correct [64], with an additional 3–5 mL/kg of fluids recommended if the individual does not produce urine or has dark or highly concentrated urine [63,65]. Although handball athletes appear to comply with daily fluid AIs [18,19], no studies have assessed fluid and electrolyte intake in the pre-sport period. Only Ferigollo et al. [24] assessed the previous hydration status of Brazilian track handball players by BIA with mean values of 71 ± 0.65% of total body water, although confounding factors and the lack of precision and accuracy of the method limit its use for monitoring hydration [65].

During exercise, the amount and rate of fluid replacement depends on individual sweat rate, duration and drinking opportunities [63]. As a general rule, during high-intensity physical activity and adverse environmental conditions, intakes of 0.6–1 L/h with frequent intakes (150–250 mL) every 15–20 min and sodium concentrations of 0.5–0.7 g/L are recommended [66], amounts achieved by most female handball athletes (200–800 mL and 1.38 ± 0.64 L) [20,22]. In addition, losses below approximately 2% of body weight when environmental conditions are warm and humid appear to compromise cognitive, skill and physical domains in team sports [67]. No included study observed losses greater than 2 kg during training and competition in track handball players [22,24]. This may be due to the greater number of drinking opportunities offered by the sport of both beach and court handball, and the lower risk of dehydration compared to other team sports [68]. However, there is a need for personalised hydration strategies during handball given the wide variability in sweat rates of athletes, with particular interest in contexts that compromise a state of euhydration such as young athletes [69], and/or matches/training of longer duration [22] with more time at high intensities (>90% FCmax) [23]. Furthermore, the results obtained in sweat tests must be correctly interpreted as being applicable to the specific samples and conditions under which the test was performed and under the same methods [70]. More studies are needed that relate fluid intakes to the individualised needs of handball athletes, rather than isolated intakes [20,21], as well as studies that reflect the water demands of handball, especially beach handball, where environmental conditions, clothing, playing time, etc., can have a significant influence on the water balance of athletes and thus on their performance and health [62,71].

After exercise, the goal is to replace any fluid and electrolyte deficits. Athletes seeking rapid and complete recovery from dehydration may employ intakes of 1.5 L of fluid per kilogram of body weight lost with sufficient sodium to balance inter-individual losses, help retain fluid ingested and stimulate thirst, while if recovery time is sufficient, the inclusion of normal meals and snacks with enough water and sodium may be sufficient to replace sweat losses [63]. In this review, we observed losses of 0.19 ± 2.03 kg [22], and 38 ± 10 mmol Na/L in sweat in female athletes during matches of different competitions [23], values of sodium loss similar to other team sports such as football or basketball [72]. However, as mentioned above, these data should be interpreted with caution, taking into account factors that may affect athletes' hydration practices and not extrapolating these results to different populations of handball athletes [71].

Furthermore, the implementation of hydration education interventions could favour the improvement of hydration status and water behaviours and habits [73], making the handball athlete aware of the importance of fluid intake before, during and after sport practice on sport performance [24] and could reduce the prevalence of handball athletes with inadequate water habits [20,21].

4.2. Energy

Adequate energy intake is the cornerstone of the handball athlete's diet to support optimal body function and body composition management [10]. Among the many factors that can influence an athlete's energy requirements, such as training/competition cycle, exposure to cold, heat or altitude, injury or age, in handball it also becomes critical to aim for a certain body composition.

To estimate the caloric expenditure of the handball athlete, we find innumerable methods with different advantages and complications [74]. Teraz and Meulenberg (2019) [38] estimated by the Cunningham equation and metabolic equivalents (MET) TEE of 4054 ± 248 kcal; 4587 ± 289 kcal; and 3413 ± 193 kcal for men; and 3173 ± 176 kcal; 3602 ± 218 kcal; and 2646 ± 108 kcal for women on training, match and rest days, respectively. On the other hand, Suzuki et al. 2020 [37], using Nelson and Keytel's equation (use of HR during activity), estimated similar TEE values of 3000 ± 228, 3322 ± 253 and 2933 ± 208 kcal during 3 days of training in female handball court players, giving 1126 ± 116, 1478 ± 209 and 1103 ± 143 kcal to energy expenditure per handball training session on all 3 days, fluctuations caused by the performance of a double session on the 2nd day. Nigan et al. 2013 [22] estimated by means of pedometers EE during matches of 439.17 ± 142.81 kcal with distances covered of 3062 ± 746.3 metres, although these data must be interpreted correctly, being aware that these devices may have limitations when recording the intensity, frequency and duration of PA, in addition to the movements of the upper body so characteristic of handball [75,76]. Another interesting study by Silva et al. (2017) [44] observed TEE values of 3126 ± 520 kcal for female and 3892 ± 596 kcal/day for male indoor handball athletes at the beginning of the season using CI and DLW techniques, with a considerable increase in TEE during the main competition phase (average PAEE from 1622 ± 563 kcal/day to 2030 ± 464 kcal/day) to values of 3549 ± 317 kcal/day for women and 4526 ± 483 kcal/day for men, results that underline the importance of adequate nutritional planning that considers the different stages of the season. In their application to movements and exercises specific to the sport of handball, Fuchs et al. (2021) [42], via spiro-ergometry, observed EE ranging from 12.36 to 15.52 kcal/min during performance tests based on typical handball court exercises. Studies of this type can also be of great use in extracting and interpreting different practical tools for the measurement of EE in sport and activity in particular, such as the LPM system or inertial sensors, for example [42,77]. The application of these methods is necessary in beach handball to analyse the specific EE of this sport, although lower demands than in indoor handball are speculated, taking into account factors such as playing time, field surface, number of players, etc. [7].

Based on these data, we observe that the vast majority of handball athletes, regardless of sex and category, do not have an adequate energy intake to cover the demands of physical activity [18,25,26,28–32,35,36,38,39], with the study by Sá et al. [35] showing the older adults' higher intakes in male goalkeepers compared to the lower intakes of female front lines (3837.1 ± 1537.8 vs. 1802.6 ± 798.1 kcal/day), data that are not in accordance with the demands of track handball athletes according to their playing position [78]. Jesus et al. 2022 [43] observed a prevalence of 9.68% of clinically low AD cases during the preparatory phase in a sample of athletes from different disciplines, including seven track handball athletes.

Clinically low AE (<30 kcal/kg FFM/day) or unusual weight loss practices in handball athletes could also be the starting point for the diagnosis of eating disorders [79]. Studies included in this review observed a high prevalence of eating disorders with data up to 18.7% of athletes [60], with gender differences and significant relationships with age and body composition [61]. Therefore, early detection of these symptoms should be a priority in the nutritional programmes of these athletes, especially in high-risk populations such as adolescents or female athletes [79–81]. Moreover, given the wide range of nutritional information that falls on these athletes (TV, magazines, radio, colleagues, coaches, etc.), the implementation of an education programme on the players themselves, coaches or health professionals involved may be a key factor in the primary prevention of eating disorders and low AE in both male and female track and beach handball athletes [21,28,40,49,79,82,83].

4.3. Carbohydrates

Handball, like the vast majority of team sports, intersperses repeated bouts of brief, high-intensity exercise with lower-intensity actions on a consistent basis [78,84]. Even between playing positions, there is wide variability in the number and frequency of such actions during the course of a single match [78]. In these scenarios, a decrease in muscle glycogen stores and altered muscle excitability and calcium kinetics is associated with increased central and peripheral fatigue in the form of reduced work rates, impaired skill and concentration, and increased perception of exertion [85]. The ACSM sets daily recommendations of 6–10 g CHO/kg body weight for moderate- to high-intensity exertions of 1–3 h duration [10]. Holway et al. [15], in a 2011 review of nutritional strategies for team sports, established more modest daily recommendations of around 5–7 g CHO/kg/day during the competitive phase, with these amounts being increased during periods of higher energy demand such as major competition days or periods or high-intensity double sessions [37,44]. Only athletes in three studies met the recommendations discussed above [34,37,40]. A well-controlled study by Suzuki et al. [37] even showed how female track handball players modified their CHO intake according to the daily training load (6.5 to 7.5 g/kg/day on days with the highest training load). Intakes of around 7.9 g/kg/day were observed by Waly et al. [40] in male beach handball athletes, although 80% of the athletes were not supervised by dieticians–nutritionists.

However, most of the studies included in this review show inadequate CHO intakes with respect to the aforementioned recommendations, with amounts ranging from 3.25 to 4.7 g/kg/day in males and 3.1 to 4.2 g/kg/day in females [18,25,28–30,33,35,38,39,41]. These data on low CHO intake, together with low energy intake, are consistent with those observed in other team sports disciplines and female populations [86,87], although there is currently no clear consensus on the need to establish gender-specific CHO and PRO guidelines [88].

Finally, for match or competition days, intakes of 1–4 g/kg of easily digestible CHO 2–4 h prior to the event may be recommended [15,84,89]; half-time intakes of small amounts of easily absorbable CHO of 30–60 g/h or even mouth rinses may be sufficient to replenish glycogen stores and maintain blood glucose levels during the second half [89,90]; and intakes of 1.2 g CHO/kg including CHO-dense foods and beverages for 2 h post-match are recommended to take advantage of enhanced glycogen repletion rates, especially when the recovery period between matches is short [15,36,84,91].

4.4. Proteins

An increase in muscle mass is shown to be a notable differentiating advantage between elite handball athletes and amateur subjects, especially in certain positions such as centre backs in track handball or back players in beach handball, where the older adults have the highest FFM values [92,93]. Therefore, an adequate protein intake becomes one of the fundamental nutritional aspects to support the additional gains of LBM and strength in these types of athletes [94]. Daily protein recommendations range from those proposed by the ACSN of 1.2–2.0 g PRO/kg/day [10], to daily intakes of 1.2–2.3 g/kg mentioned by Holway et al. [15] for team sport athletes. These oscillations are observed most sharply in the protein intake of the handball athletes included in this review, with intakes of 1.03–2.5 g/kg/day in females and 0.83–1.76 g/kg/day in males [18,25,29,30,35,37,39,41]. Suzuki et al. [37] observed that an average protein intake of 1.57 g/kg/day was sufficient to achieve 0 NBAL in the Japanese women's national handball team during training sessions involving strength and handball over 3 days of camp. These data can be very useful in determining the protein requirements of the handball athlete, although achieving a nitrogen balance is a secondary issue for an athlete whose primary goal is training adaptation and performance enhancement [95]. Therefore, guidelines should focus on optimal adaptation to specific sessions of a particular training programme or phase of the season, while taking into account the subject's experience, energy demand of the programme (higher or lower CHO demand) and body composition adequacy [10,96,97]. Recent reviews show positive effects of strength training programmes on throwing, isometric endurance, maximum strength and power in handball players [98], so we could speculate that intakes around the upper ranges of the recommendations could be necessary to improve skeletal muscle remodelling and stimulate adaptations during sessions or strenuous strength training programmes [99]. However, studies assessing the effects of dietary protein in strength training programmes in handball athletes are needed.

4.5. Fats

Fats are a necessary component of the healthy diet of the handball athlete given their role as an essential element of the cell membrane, in the provision and absorption of fat-soluble vitamins, and as an important energy substrate in the aerobic metabolism used during sport [7,10,78,100]. In contrast to CHO and PRO, the guidelines of different sports organisations regarding fat intake are reduced, recommending no more than 30% of energy intake from this macronutrient, with less than 10% and 1% respectively for saturated fatty acids and trans fatty acids, 7–10% for polyunsaturated fatty acids (especially omega 3 and omega 6) and the remaining percentage for monounsaturated fatty acids [10,100]. The vast majority of studies included in this review did not comply with these recommendations [25–29,35,38,39], exceeding total fat intake with values of up to 42% of energy intake in some of them [39]. Furthermore, the fat sources consumed by male and female beach and court handball athletes were dairy products [26,27,39,47,48], meats and sausages [18,26], fish [18,47], margarines [27,45], olive oil and other vegetable oils [47,49], eggs [26] and seeds and nuts [49]. These data are widely heterogeneous depending on the country of the study sample but show similar observations to data on intake and major fat sources in the European population [101]. Furthermore, they show the urgent need to seek better and more adequate nutritional planning for handball athletes in relation to fatty acid intake. Reduced fat intakes may be especially advisable at times close to matches or high intensity training, to avoid possible gastrointestinal discomfort [10,102,103], or fat loss protocols during specific training programmes or phases of the season [104].

4.6. Fibre

An adequate intake of dietary fibre is of great importance for the handball athlete, not only because of its wide-ranging effects on health [105], but also because of its possible effects on the intestinal microbiota and the possible disorders that may occur after the stress to which the gastrointestinal tract is subjected during handball sport [106,107]. Although there is currently a clear inconsistency in fibre recommendations between countries [108], high-level organisations such as the American Dietetic Association establish recommended intakes of approximately 14 g of dietary fibre per 1000 kcal, or 25 g and 38 g, respectively, for adult women and men [109]. In handball athletes, highly variable fibre intakes are observed, with amounts of 41.74 $\pm$ 22.03 g/day reported by Caprio et al. [25] in Brazilian junior players, or remarkably low average intakes of around 4 g in Turkish elite players [29]. These data are consistent with the dietary habits and poor intake of fibre sources in this type of athlete, especially fresh fruit and vegetables [27,45,47–49]. In addition, the article by Martínez-Rodríguez et al. [47] included in this review observed that 9.5% and 20% of elite female and male beach handball players, respectively, had low adherence to the Mediterranean diet, which could be an added risk factor for diseases associated with the intestinal microbiota [110]. These data show once again the need to consider more appropriate nutritional strategies in this population group, away from a westernised style of diet, where the frequent consumption of snacks and low palatability foods with a high energy density can also compromise the health of handball athletes [19,39,45,46,48,111].

4.7. Vitamins

Much of the literature collected in this review pays special attention to vitamin D intake and status in handball athletes. The effects of insufficient 25-OH-D3 levels on sports performance and the risk of injury are now widely understood [112–114]. In handball athletes it has been observed that although athletes have an adequate dietary intake of vitamin D [51,52], a large proportion of them have insufficient (<30 ng/mL) or deficient (<20 ng/mL) serum levels of 25-OH-D3 [50,54,55,59]. Valtueña et al. [59] even showed how serum vitamin D levels failed to reverse with the use of supplementation, something that did happen with outdoor athletes, which may call for greater attention to vitamin D in court handball players compared to those in outdoor disciplines such as beach handball. These data highlight the importance of monitoring this micronutrient in indoor sports such as court handball, as well as taking into account several additional factors that may influence the vitamin D status of handball athletes, such as the race of the athlete, teams or players from higher latitudes, and times of lower sun exposure such as winter or early spring [115]. In relation to other vitamins, only two studies showed insufficient intakes of B1, B2, B12 and folic acid [29,33,53]. These data should be interpreted correctly, as reference values for micronutrient intakes vary depending on the study and the country of the selected sample. However, it could be speculated that handball athletes may have an older adult requirement for riboflavin and vitamin B6 because of their involvement in the main energy pathways during exercise [33,116,117], while others such as vitamin B12 or folic acid involved in cell synthesis and repair do not seem to show special differences with handball practice, although a low intake of plant-based foods or special situations such as following vegetarian diets or periods of pregnancy could compromise the status of some of these micronutrients in handball athletes [53,116,118,119]. In addition, handball athletes should pay greater attention to the specific needs of different vitamins and micronutrients related to antioxidant capacity due to the increase in biomarkers of oxidative stress produced, especially during periods of higher intensity training and competition [120,121]. A greater adequacy of intake of these antioxidant capacity vitamins in handball athletes is required [22,30,36].

4.8. Minerals

Most of the studies included in this review that refer to micronutrients include data on iron intake and status in male and female handball players. All studies with female athletes showed intake values below recommendations [26,29–31], or ferritin levels <30 ng/dL and/or Hb values <12 ng/dL [31,45,56–58]. These data are in agreement with other observations made in other athletes in ball team sports, yielding worrying data on the sports performance of these athletes related to iron status [122,123]. Furthermore, these values contrast markedly with the male population, where a better dietary iron intake is observed within male vs. female handball players themselves [35,51]. These data suggest the need to establish dietary interventions with iron (e.g., diet rich in Fe and heme iron, intake of synergistic compounds that favour Fe absorption such as vitamin C, avoiding Fe-rich foods with high levels of hepcidin, etc.), given the possible increase in iron requirements of female athletes after handball [10,22,123,124].

Low calcium intake may contribute to an added risk of low bone mineral density and risk of fractures, especially in athletes with low energy availability [10,125]. Calcium intakes in handball athletes are shown to be highly variable between different handball athletes [18,25,29,30,52]. However, several studies show calcium intakes well below the RDA, accompanied by very low energy intakes in both male and female handball athletes [18,25,29]. This could be of concern given the lower BMC and BMD values in handball athletes with lower calcium intakes and sun exposure [52]. Intakes of 1500 mg of calcium per day may be recommended to optimise bone health in handball athletes with low energy availability or those players with menstrual dysfunction [10]. However, further studies are needed to evaluate calcium recommendations in relation to adequate energy intake and vitamin D status on bone health in handball athletes of different disciplines and ages. Finally, some studies show lower than recommended intakes of magnesium in the diets of handball athletes [18,32]. Only one study involving male and female handball players met the RDA of 400–420 mg/day for males aged 14–70 years and 310–320 mg/day for females aged 14–70 years [35,126]. These data are consistent with other observations in athlete and non-athlete populations and point to the importance of assessing this micronutrient in handball athletes for proper muscle function [18,127,128].

4.9. Limitations

In addition to the limitations of the methods used in the included studies (dietary records, blood samples, questionnaires, etc.), the main limitation of this review is the wide heterogeneity in the included studies. Due to this heterogeneity in the different aspects covered in this review (hydration, macronutrients, vitamins, minerals, etc.) and also present in the included studies with samples of handball athletes from different disciplines, no risk of bias assessment was performed on the 44 articles of the main search.

This review presents notable differences in the sample, year of study and country, and methods of the included studies from each other. A small sample size with a wide heterogeneity of the included studies makes it difficult to assess the intake of this population group and its adequacy to the specific demands of the sport of handball. Future research should expand the knowledge on the nutritional demands of these athletes in order to establish adequate consumption patterns adapted to each specific group.

5. Conclusions

The majority of handball athletes of different genders and ages do not show a nutritional status in accordance with the water, energy and macro and micronutrient demands of the sport in question. However, these specific demands for each modality do not seem to be very clear at present, and more research is needed in this respect in the future.

An adjustment in water and energy intake, based on a reduction in the consumption of fats and an increase in carbohydrates, could be advisable in handball athletes close to the start of the sport. Micronutrients such as vitamin D, B6, riboflavin, iron, calcium, magnesium and others with antioxidant capacity may require greater vigilance in this type of athlete.

Likewise, the limited knowledge of sports nutrition and the unreliability of the information sources used by handball athletes show the need for a greater integration of professional figures in sports nutrition (such as sports dieticians–nutritionists) within beach and court handball teams.

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