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Nutritional challenges in para-athletes: A scoping review of current knowledge

Daniele Conte [a,*], Annalisa Di Nucci [a,b], Giuliana De Maio [c,d], Maria Parpinel [a]

[a] Department of Medicine (DMED), University of Udine, 33100, Udine, Italy
[b] Department of Cardiovascular, Endocrine-Metabolic Diseases and Aging, Istituto Superiore di Sanità, 00161, Roma, Italy
[c] School of Physiotherapy, Department of Medicine (DMED), University of Udine, 33100, Udine, Italy
[d] Institute of Physical Medicine and Rehabilitation "Gervasutta", Friuli Centrale University Health Authority, 33100, Udine, Italy

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ABSTRACT

Background: Para-athletes face unique nutritional challenges arising from impairment-specific physiological and metabolic characteristics, along with environmental and economic barriers influencing food access and meal preparation. Despite the rapid growth of parasport, evidence guiding nutritional practice in this population remains limited.

Objective: This scoping review systematically mapped the literature on dietary intake and supplement use among para-athletes, identifying key nutritional challenges and research gaps across impairment types, sports, and competition levels.

Methods: Following the Joanna Briggs Institute and PRISMA-ScR frameworks, five databases were searched. Studies including para-athletes of any impairment, sport, or competitive level were eligible. Data were synthesized across seven domains: macronutrient and fiber intake, micronutrient intake, supplement use, hydration status, alcohol consumption, low energy availability, and dietary habits. Dietary intake was assessed against reference standards. Methodological quality assessment of the included studies was also performed with appropriate tools.

Results: Forty-seven studies were included. Across impairment groups, carbohydrate and fiber intakes were often below recommendations, while protein intake was generally adequate but insufficient in some female athletes. Vitamin D, calcium, magnesium, and iron inadequacies were common, alongside elevated sodium and B vitamin intakes. Supplement use ranged from 0% to 91%, dominated by vitamin/mineral, creatine, and omega-3 products. Evidence on hydration, alcohol use, low energy availability, and dietary habits was scarce but indicated potential health risks.

Conclusions: Para-athletes face distinct and recurring nutritional challenges that impact sport performance and long-term health. Addressing these gaps through impairment-specific research and integrated nutrition care is essential to optimize performance and health in parasport.

1. Introduction

Para-athletes, defined as individuals with physical, visual, or intellectual impairments who participate in organized sport, represent a rapidly growing and increasingly visible segment of the athletic population. The professionalisation of parasport and the global reach of events such as the Paralympic Games have underscored the importance of optimizing all aspects of preparation, including nutrition, for both performance and long-term health.[1]

Sports nutrition is an expanding and increasingly sophisticated field, supported by numerous evidence-based guidelines and position stands that outline its critical role in enhancing training adaptation, recovery, and overall athletic performance in able-bodied populations. However, para-athletes remain markedly underrepresented in this literature, and their nutritional requirements cannot simply be extrapolated from those of able-bodied athletes.[2] Many impairments are associated with distinct physiological and metabolic characteristics that may alter energy needs, substrate utilization, nutrient digestion and absorption, and

* Corresponding author. Department of Medicine, University of Udine, Via Colugna, 50, 33100, Udine, Italy.
E-mail addresses: conte.daniele@spes.uniud.it (D. Conte), dinucci.annalisa@spes.uniud.it (A. Di Nucci), giuliana.demaio@uniud.it (G.D. Maio), maria.parpinel@uniud.it (M. Parpinel).

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micronutrient requirements. For example, spinal cord injury (SCI) is characterized by reduced resting energy expenditure, altered body composition, and increased risk of metabolic and micronutrient imbalances.[3] Athletes with cerebral palsy often face oromotor dysfunction, gastrointestinal dysmotility, and higher energy demands for movement due to spasticity.[4] In athletes with limb amputation, the combination of reduced lean mass and increased locomotor energy cost when using prostheses poses unique challenges in balancing energy intake.[5] Moreover, athletes with impairments may be particularly vulnerable to low energy availability (LEA), a state in which dietary energy intake fails to compensate for exercise energy expenditure and underlying physiological demands, with potential adverse consequences for bone, metabolic and endocrine health. This is due to impairment-related alterations in body composition and metabolic regulation, as well as challenges in accurately estimating energy needs.[6] Together, these factors underscore the importance of personalized nutrition approaches that reflect the distinct physiological and functional characteristics of para-athletes.

Dietary supplement use represents another area of relevance. While supplementation is widespread among able-bodied athletes, driven by performance, recovery, and health-related goals, the prevalence, motivations, safety, and potential drug-supplement interactions in para-athletes remain poorly characterized. This gap is clinically relevant, as inappropriate or unsupervised supplementation may lead to adverse health effects and anti-doping violations.[7]

Taken together, these factors underscore the need for a comprehensive synthesis of existing evidence. To date, no review has systematically mapped the nutritional intake, and supplement use of para-athletes across different impairment types, sports, and competitive levels. The aim of this scoping review is therefore to systematically map and critically synthesize the available evidence on dietary intake, and supplement use among para-athletes. Beyond describing current knowledge, this work identifies recurrent nutritional challenges to raise clinical awareness in this topic and provide a foundation for evidence-based, impairment-specific nutritional strategies applicable across both elite and non-elite para-sport contexts.

2. Materials and methods

This scoping review was conducted in accordance with the methodological guidance of the Joanna Briggs Institute for scoping reviews. Reporting follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). The review protocol was prospectively registered in the Open Science Framework registries (https://doi.org/10.17605/OSF.IO/74XFB).

2.1. Search strategy

The primary research question guiding this review was: *"What specific aspects of para-athletes' diets have been investigated in the literature (*e.g., *diet quality, nutrient intake, supplement use, etc.)?"*

The search strategy was developed according to the Population–Concept–Context (PCC) framework. The Population of interest included athletes with any type of disability, encompassing both professional and amateur levels. The Concept focused on studies evaluating nutritional status, dietary habits, or supplement use, assessed with any type of measurement tool. Dietary supplements were defined as products intentionally consumed in addition to the habitual diet to achieve a health or performance benefit, including both traditional supplements and sport foods (e.g., sport drinks, gels, bars).[7] The Context was unrestricted about setting, sport discipline, or geographic location.

A comprehensive search was conducted up to February 2, 2025 in the following electronic databases: MEDLINE (via PubMed), Scopus, Web of Science, and Google Scholar (the latter used to capture grey literature). To develop the search strings, an initial limited search of MEDLINE was performed to identify key articles on the topic. Text words contained in the titles and abstracts of relevant articles, as well as index terms used to describe them, were analyzed to generate a full search strategy. This strategy was then iteratively refined and adapted to the syntax and indexing of each database using appropriate Boolean operators and truncation commands.

In addition to the primary database search, citation chasing was performed for all included articles using the *citationchaser* software, applying both backward (reference list) and forward (citing articles) approaches to identify additional eligible records.

The complete search strings for each database are provided in the Supplementary Material S1.

2.2. Study selection

All citations retrieved from the database searches were imported into Zotero reference management software for organization and initial handling. Duplicate records were identified and removed using the Deduplicator tool to generate a single set of unique references. Screening was then conducted in Rayyan following a two-step process:

1. Title and abstract screening,
2. Full-text assessment of potentially eligible articles.

Each phase of screening was carried out independently and in duplicate by two reviewers working in double-blind. Before formal screening began, a pilot testing phase was undertaken to ensure consistent understanding and application of the predefined inclusion and exclusion criteria. The review team comprised researchers with clinical expertise in the management of athletes and individuals with disabilities, and with advanced training in nutrition, ensuring both methodological rigor and content-specific expertise throughout the selection process.

Disagreements at any stage were first resolved through discussion between the two primary reviewers; when consensus could not be reached, a third reviewer provided adjudication. The same multi-step procedure, including duplicate independent screening of titles/abstracts and full texts, as well as conflict resolution, was applied to records identified through citation chasing, ensuring methodological consistency between the primary database search and the secondary reference screening.

2.3. Data extraction and analysis

Data extraction was performed independently by two reviewers using a predesigned Microsoft Excel spreadsheet specifically developed for this review. Prior to formal extraction, a pilot testing phase was conducted on a sample of included studies to ensure clarity and consistency in data collection. Extracted data were then cross-checked by a third reviewer, and any discrepancies were resolved through discussion among all three reviewers until consensus was reached.

For each included study, a broad range of information was collected to capture both general study characteristics and nutrition-related findings. This included bibliographic details (e.g., author, year, country), key population descriptors (e.g., sample size, sex, type of disability, sport discipline), methodological aspects, and all relevant outcomes regarding dietary intake, nutritional status, or supplement use. The extracted data were subsequently organized into predefined nutritional domains (macronutrient intake, micronutrient intake, supplement use, hydration status, alcohol consumption, and low energy availability, dietary habits) to facilitate descriptive synthesis of the evidence. Definitions of adequate or excessive intake were based on the criteria and reference values adopted in each individual study (e.g., Estimated Average Requirement, Recommended Dietary Allowance, Tolerable Upper Intake Level, or country-specific guidelines), as reported by the original authors.

2.4. Methodological quality assessment

Although formal quality appraisal is not mandatory in scoping reviews, a methodological quality assessment was conducted to provide an overview of the general robustness of the available evidence in this field. Two reviewers independently assessed the quality of all included studies using the National Institutes of Health (NIH) Quality Assessment Tools, selecting the appropriate checklist according to the study design (i.e., Observational Cohort and Cross-Sectional Studies, Before–After [Pre–Post] Studies With No Control Group, or Controlled Intervention Studies). Any disagreements were resolved through discussion, and when necessary, a third reviewer was consulted to reach consensus. This approach allowed for a structured evaluation of potential sources of bias and methodological limitations, providing valuable context for interpreting the findings of the review.

3. Results

3.1. Selection process

The database search yielded a total of 1181 records, of which 217 were identified as duplicates and removed. Screening of the remaining 964 titles and abstracts led to the exclusion of 864 records, leaving 100 articles for full-text review. Of these, 8 full texts could not be retrieved, resulting in 92 articles assessed in full. Following full-text evaluation, 54 articles were excluded for the following reasons: foreign language (n = 18), wrong outcome (n = 16), duplicate publication (n = 8), wrong population (n = 3), and wrong publication type (n = 1). A total of 46 studies were therefore included from the primary database search.

Citation chasing was performed on the 46 included studies. Backward reference screening identified 608 unique records, and forward citation tracking identified an additional 188 unique records, for a total of 796 records. After deduplication with the primary search, 588 unique records remained. Title and abstract screening excluded 585 records, leaving 3 full texts for eligibility assessment. Of these, 2 were excluded for wrong outcome, and 1 was included.

In total, 47 studies met the inclusion criteria and were incorporated into the final synthesis. A detailed flow of the study selection process is presented in the PRISMA flow diagram (Fig. 1) while the full list of excluded articles with the corresponding reasons for exclusion at the full-text stage is provided in the Supplementary Material S2.

3.2. Characteristics of included studies

A total of 47 studies were included in this review. The geographical distribution of the included studies is illustrated in Fig. 2.

The study populations were heterogeneous, encompassing athletes with spinal cord injury, cerebral palsy, limb amputations, visual or intellectual impairments, as well as mixed cohorts including athletes with different types of disabilities. Overall, 22 studies (47%) included mixed populations, 14 (30%) did not clearly specify the impairment type, 7 studies (15%) focused exclusively on athletes with spinal cord injury, 2 (4%) on those with deafness, 1 (2%) on amputee athletes, 1 (2%) on athletes with intellectual impairments (Fig. 3a).

Regarding sport discipline, 18 studies (38%) included mixed sports, 12 (26%) focused on team sports (e.g., wheelchair basketball, football), 8 studies (17%) investigated endurance sports (e.g., wheelchair racing, cycling), 7 (15%) did not specify the type of sport, while 2 studies (4%) included mixed-type sports (e.g., Track&Field) (Fig. 3b). In terms of competitive level, 21 studies (45%) examined elite or Paralympic-level athletes, 17 (36%) did not provide sufficient detail to classify competition level, 7 (15%) recruited mixed-level samples, and 2 (4%) included non-elite or recreational athletes.

Across the seven domains of interest, 32 studies (68%) addressed macronutrient and fiber intake, 27 (57%) investigated micronutrient status, 17 (36%) focused on dietary supplement use, 8 (17%) explored alcohol consumption, 5 (11%) examined hydration status, 5 (11%) assessed dietary habits, and 4 (9%) assessed low energy availability.

Regarding dietary assessment methods, 17 studies employed Food Frequency Questionnaires (FFQs), of which 8 (47%) used validated tools

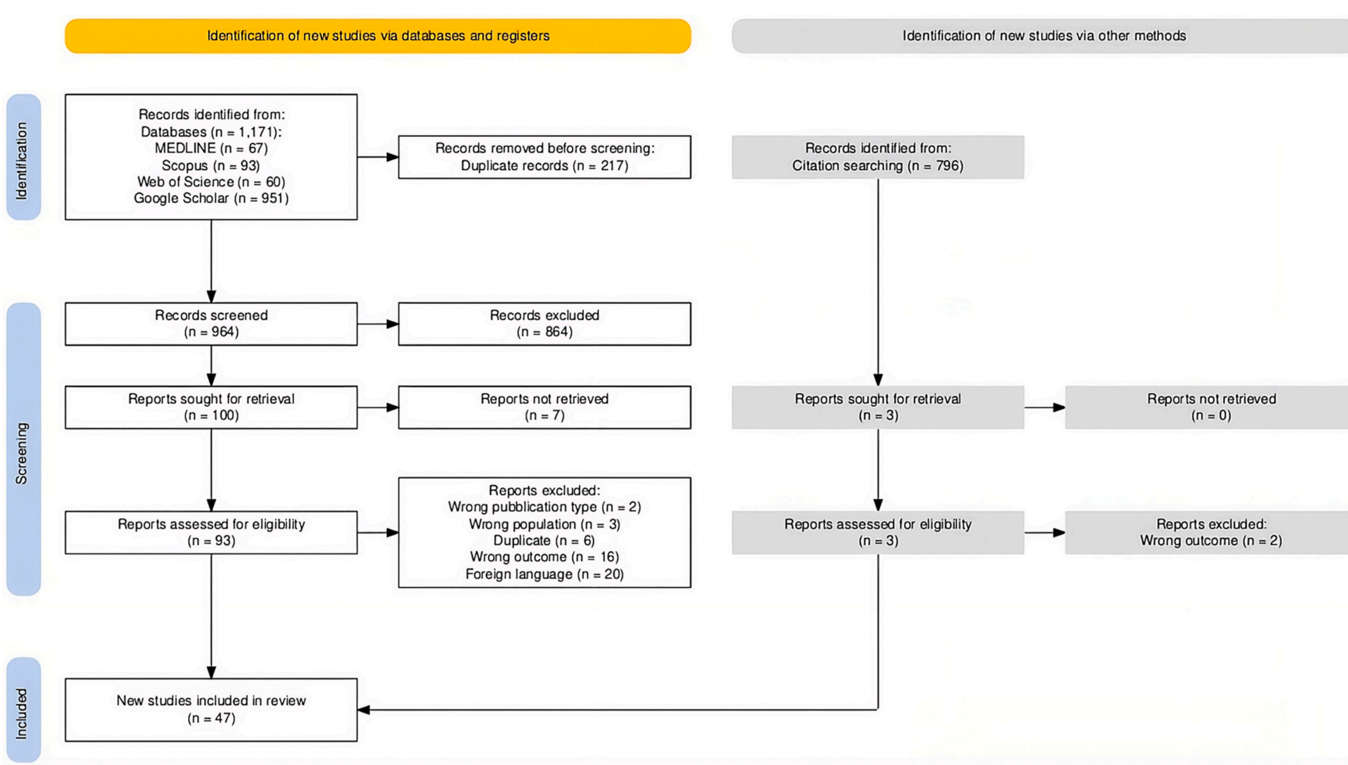

Fig. 1. PRISMA flow diagram illustrating the study selection process.

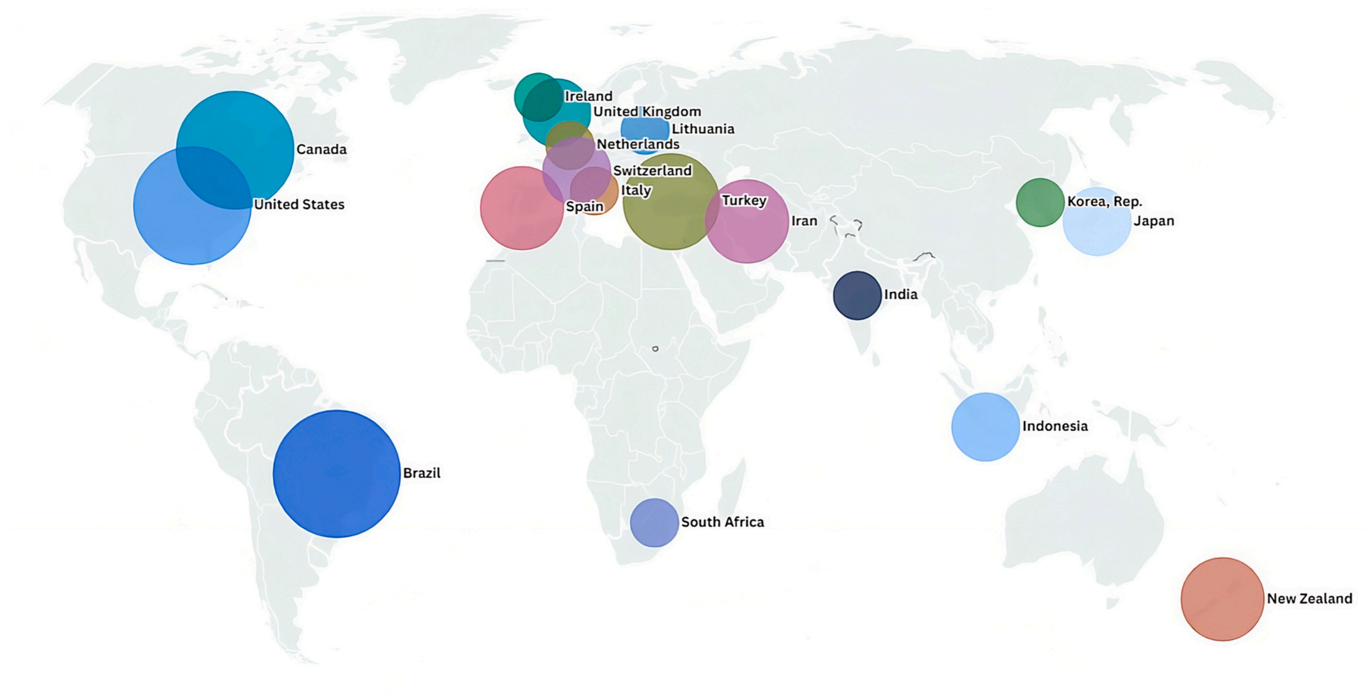

Fig. 2. Geographic distribution of included studies. Circle size is proportional to the number of studies conducted in each country.

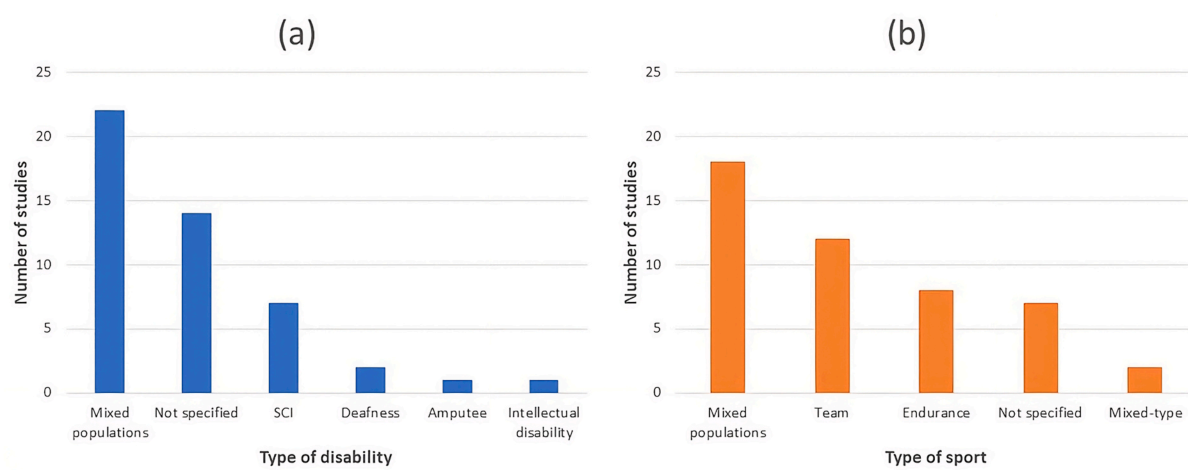

Fig. 3. Distribution of participant characteristics across included studies. (a) Type of disability represented in the study populations. (b) Type of sport practiced by participants.
"Mixed populations" refers to studies including athletes from multiple different sports, while "mixed-type" denotes sports with both aerobic and anaerobic components.

and 9 (53%) used non-validated versions. Dietary records were reported in 14 studies, most commonly 3-day records (n = 7), followed by 7-day (n = 5), 4-day (n = 1), and 6-day (n = 1) protocols. 11 studies applied dietary recalls, including 6 single 24-h recalls, 2 two-day 24-h recalls, 2 three-day 24-h recalls, and 1 seven-day recall. 2 studies used combined methods: one integrating a 3-day food record with a validated supplement questionnaire, and another combining a 24-h recall with a validated FFQ.

The general characteristics of the included studies are summarized in Table 1.

3.3. Quality assessment

A total of 47 studies were assessed for methodological quality. Among these, 20 were rated as good, 20 as fair, and 1 as poor. Overall, the majority of studies demonstrated at least a fair level of quality, with less than half achieving the highest rating. The domains showing the greatest limitations, with frequent "No" and "Cannot Determine" ratings, were those related to the clear specification and definition of the study population, and to the justification of sample size, indicating recurrent methodological weaknesses in these areas.

The detailed results of the methodological quality assessment for each included study are provided in Supplementary S3.

3.4. Nutritional domains

A comprehensive synthesis of the key findings and potential issues within each nutritional domain is provided in Table 2. In addition, Fig. 4

Table 1
General characteristics of the included studies.

Author, year	Study type	Total sample	Athletes nationality	Mean age	Gender	Condition	Sport	Sport level	Domains assessed	Measurement tools
Hedrick, 1988[8]	Cross-sectional	36	NR	29.97 (6.61)	M (63%) F (37%)	SCI (74%) Polio (17%) Spina bifida (9%)	Wheelchair racing (100%)	Elite	③ Supplement use ⑤Alcohol consumption	Non validated questionnaire
Wang, 1992[9]	Cross-sectional	29	USA (55%) Japanese (41%) New Zealand (4%)	34.2 (9.7)	M (93%) F (7%)	SCI (76%) Polio (10%) Other (14%)	Wheelchair racing (100%)	NR	① Macronutrient intake ② Micronutrient intake ③ Supplement use	Non validated questionnaire
Watanabe, 1992[10]	Cross-sectional	39	NR	31.1 (7.8)	M (77%) F (23%)	SCI (64%) Polio (10%) Spina bifida (5%) MS (5%) Blind (5%) Mental impairment (5%) Arteriovenal malformation (3%) Spinal tuberculosis (3%)	Wheelchair racing (36%) Track&Field (16%) Swimming (13%) Table tennis (13%) Archery (7%) Shooting (7%) Special Olympics track (5%) Weightlifting (3%)	NR	① Macronutrient intake ③ Supplement use ⑤Alcohol consumption ⑦ Dietary habits	Non validated questionnaire
Perols, 2000[11]	Cross-sectional	16	New Zealand (100%)	29.8 (6.8)	M (100%) F (0%)	SCI (100%)	Wheelchair racing (100%)	NR	① Macronutrient intake ② Micronutrient intake ⑤Alcohol consumption	7-day dietary record
Ribeiro, 2005[12]	Cross-sectional	60	Brazilian (100%)	18-40	M (100%) F (0%)	Polio (53%) SCI (47%)	Wheelchair basketball (100%)	NR	① Macronutrient intake ② Micronutrient intake	3-day 24-h dietary recall
Da Silva Gomes, 2006[13]	Cross-sectional	15	Brazilian (100%)	32.3 (6.3)	M (100%) F (0%)	Transfemoral amputation (80%) Upper limb amputation (13%) Transtibial amputation (7%)	Amputee soccer (100%)	Elite	① Macronutrient intake ② Micronutrient intake ③ Supplement use	6-day dietary record
Rastmanesh, 2007[14]	nRCT	72	Iranian (100%)	30 (7.6)	NR	SCI (82%) Amputation (18%)	NR	Elite (92%) NR (8%)	② Micronutrient intake	3-day dietary record
Goosey Tolfrey, 2010[15]	Cross-sectional	23	British (100%)	26.08 (7.69)	M (39%) F (61%)	Chronic arthritis SCI Brittle bones Dystrophic dysplacia MS Lower limb nerve damage	Wheelchair basketball (52%) Wheelchair tennis (48%)	Elite (100%)	① Macronutrient intake	7-day dietary record
Krempien, 2011[16]	Cross-sectional	32	Canadian (100%)	30.6 (6.2)	M (75%) F (25%)	SCI (100%)	Wheelchair rugby (63%) Wheelchair basketball (22%) Para-Alpine skiing (9%) Track&Field (6%)	Elite	① Macronutrient intake ② Micronutrient intake ③ Supplement use	3-day dietary record
Shaw, 2013[17]	Cross-sectional	18	New Zealand (100%)	40.1 (11.0)	M (78%) F (22%)	SCI (100%)	NR	NR	③ Supplement use	Non validated questionnaire
Magee, 2013[18]	nRCT	33	Irish (100%)	31.0 (13.17)	M (73%) F (27%)	NR	NR	Elite	② Micronutrient intake	Validated FFQ

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Table 1 (*continued*)

Author, year	Study type	Total sample	Athletes nationality	Mean age	Gender	Condition	Sport	Sport level	Domains assessed	Measurement tools
Black, 2013[19]	Cross-sectional	12	NR	31.25 (5.23)	M (100%) F (0%)	SCI (100%)	Wheelchair rugby (100%)	Elite	④ Hydratation status	USG
Tolfrey, 2014[20]	Cross-sectional	399	British (44%) USA (14%) Swiss (14%) German (8%) Brazilian (6%)	>18	M (74%) F (26%)	NR	Wheelchair rugby (20%) Wheelchair basketball (12%) Wheelchair tennis (10%) Track&Field (8%) Sitting volleyball (7%) Para cycling (6%)	Elite (64%) Non elite (36%)	③ Supplement use	Non validated questionnaire
Rosety, 2016[21]	Cross-sectional	22	NR	18-30	M (100%) F (100%)	Intellectual disability (100%)	NR	NR	④ Hydratation status	USG
Eskici, 2016[22]	Cross- sectional	22	Turkish (100%)	25.5 (7.2)	M (0%) F (100%)	Lower limb amputee (100%)	Wheelchair basketball (100%)	Elite	① Macronutrient intake ② Micronutrient intake ④ Hydratation status ⑤Alcohol consumption	Validated FFQ
Grams, 2016[23]	Before-after study	17	Spanish (100%)	30.33 (16.98)	M (100%) F (0%)	SCI (71%) Amputee (29%)	Wheelchair basketball (100%)	Elite	① Macronutrient intake ② Micronutrient intake	Food weighting record
Pritchett, 2016[24]	Observational Cohort	39	NR	27.7 (6.5)	M (49%) F (51%)	SCI (100%)	Track&Field (36%) Wheelchair rugby (31%) Wheelchair basketball (31%) Wheelchair tennis (2%)	NR	② Micronutrient intake	Non validated questionnaire
Amirsasan, 2017[25]	Cross-sectional	35	Iranian (100%)	36.69 (9.83)	M (69%) F (31%)	Polio (80%) Amputee (11%) SCI (6%) Visually impaired (3%)	Sitting volleyball Wheelchair basketball Track&Field Wheelchair tennis Swimming Para cycling Weightlifting Shooting Football 5-a-side	Elite	① Macronutrient intake ② Micronutrient intake	3-day dietary record
Broman, 2017[26]	Observational Cohort	242	NR	26.02 (5.14)	M (100%) F (0%)	Cerebral palsy Visually impaired	Football (100%)	Elite	③ Supplement use	Interview
Ferro, 2017[27]	Observational Cohort	11	Spanish (100%)	30.0 (6.0)	M (100%) F (0%)	SCI (73%) Amputee (27%)	Wheelchair basketball (100%)	Elite	① Macronutrient intake ⑦ Dietary habits	3-day dietary record
Madden, 2017[28]	Cross-sectional	40	NR	26.0 (20.5-33.5)	M (45%) F (55%)	NR	Wheelchair basketball (69%) Para cycling (8%)	Provincial (5%) National (8%) International (87%)	① Macronutrient intake ② Micronutrient	3-day dietary record Validated supplement questionnaire

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Table 1 (*continued*)

Author, year	Study type	Total sample	Athletes nationality	Mean age	Gender	Condition	Sport	Sport level	Domains assessed	Measurement tools
							Sitting volleyball (5%) Wheelchair curling (5%) Goalball (5%) Sit Skiing (2%) Para Bobsleigh (2%) Para soccer (2%) Para rugby (2%)		intake ③ Supplement use	
Cengizhan, 2018[29]	Cross-sectional	74	Turkish (100%)	23.62 (5.38)	M (85%) F (15%)	Deafness (100%)	Basketball (28%) Taekwondo (24%) Handball (22%) Volleyball (18%) Swimming (8%)	NR	③ Supplement use	Non validated questionnaire
Madden, 2018[30]	Cross-sectional	42	Canadian (100%)	36.3 (9.5)	M (79%) F (21%)	NR	Wheelchair rugby (100%)	Provincial (12%) National (57%) International (13%)	③ Supplement use	Non validated questionnaire
Rodrigues, 2018[31]	Observational Cohort	10	Brazilian (100%)	29.1 (6.06)	M (60%) F (40%)	Visually impaired (40%) Cerebral palsy (30%) Amputee (30%)	Track&Field (100%)	Elite	① Macronutrient intake	24-h dietary recall
DiFolco, 2019[32]	Cross-sectional	8	USA (100%)	26.89 (6.58)	M (0%) F (100%)	SCI (100%)	NR	NR	① Macronutrient intake ⑥Low energy availability	7-day dietary record LEAF-Q
Joaquim, 2019[33]	Cross-sectional	20	Brazilian (100%)	24.95 (6.28)	M (65%) F (35%)	Visually impaired (65%) Cerebral palsy (20%) Limb deficiency (15%)	Track&Field (100%)	NR	① Macronutrient intake	4-day photographic register
Penggalih, 2019[34]	Cross-sectional	18	Indonesian (100%)	15-34	M (89%) F (11%)	Physical impairment (67%) Intellectual impairment (22%) Visual impairment (11%)	Swimming (100%)	NR	① Macronutrient intake ② Micronutrient intake ④ Hydratation status	24-h dietary recall
Shimizu, 2019[35]	Cross-sectional	13	Japanese (100%)	28.9 (8.1)	M (0%) F (100%)	SCI (62%) Skeletal systema disorders (38%)	Wheelchair basketball (100%)	Elite	① Macronutrient intake ② Micronutrient intake	Validated FFQ
Baranauskas. 2020[36]	Cross-sectional	14	Lithuanian (100%)	26.4 (4.5)	M (0%) F (100%)	Deafness (100%)	Basketball (100%)	Elite	① Macronutrient intake ② Micronutrient intake	7-day dietary recall
Egger, 2020[37]	Cross-sectional	14	Swiss (100%)	34.9 (9.4)	M (57%) F (43%)	SCI (64%) Spina bifida (29%) MS (7%)	Para cycling (44%) Track&Field (21%) Badminton (21%) Wheelchai tennis (7%) Wheelchair basketball (7%)	Elite	① Macronutrient intake ⑥Low energy availability	7-day dietary record
Sasaki, 2021[38]	Cross-sectional	101	Brazilian (100%)	33.3 (9.83)	M (81%) F (19%)	NR	Football (13%) Basketball (11%) Swimming (11%) Badminton (9%) Powerlifting (9%) Archery (8%) Track&Field (8%)	NR	② Micronutrient intake	2-day 24-h dietary recall

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Table 1 (*continued*)

Author, year	Study type	Total sample	Athletes nationality	Mean age	Gender	Condition	Sport	Sport level	Domains assessed	Measurement tools
							Wheelchair rugby (8%) Wheelchair tennis (8%) Sitting volleyball (6%) Boccie (3%) Equestrianism (3%) Sailing (3%)			
Jeoung, 2021[39]	Cross-sectional	21	Korean (100%)	NR	M (76%) F (24%)	SCI (76%) Cerebral palsy (14%) Visual impairment (10%)	Archery (18%) Shooting (14%) Boccia (14%) Badminton (14%) Table tennis (9%) Track&Field (9%) Judo (9%) Track cycling (9%) Swimming (4%)	Elite	① Macronutrient intake ② Micronutrient intake	24-h dietary recall
Pritchett, 2021[40]	Cross-sectional	18	USA Canadian	27.0 (7.3)	M (50%) F (50%)	NR	Wheelchair racing (88%) Basketball (22%)	NR	⑥Low energy availability	7-day dietary record LEAF-Q
Shaw, 2021[41]	Observational Cohort	25	Canadian (32%) Australian (28%) USA (24%) British (8%) South African (4%) Belgian (4%)	37.8 (9.3)	M (40%) F (60%)	NR	Para cycling (96%) Para triathlon (4%)	Elite	① Macronutrient intake ② Micronutrient intake	Validated FFQ
Al Rubaye, 2022[42]	Cross-sectional	100	Iranian (100%)	34.75 (10.13)	M (67%) F (33%)	NR	NR	NR	② Micronutrient intake	Validated FFQ
Gordon, 2022[43]	Cross-sectional	12	South African (100%)	44.0 (9.3)	M (83%) F (17%)	SCI (100%)	Para cycling (100%)	National level (100%)	① Macronutrient intake ② Micronutrient intake ③ Supplement use	Validated FFQ
Sukur, 2022[44]	Cross-sectional	90	Indonesian (100%)	NR	NR	NR	Swimming (22%) Badminton (19%) Table tennis (13%) Track&Field (11%) Blind judo (9%) Chess (8%) Wheelchair tennis (7%) Archery (4%) Boccia (4%) Shooting (3%)	National level (100%)	① Macronutrient intake	24-h dietary recall
Toti, 2022[45]	Cross-sectional	15	Italian (100%)	28.5 (1.5)	M (100%) F (0%)	SCI (40%) Amputee (33%) Other (20%) Spina bifida (7%)	Wheelchair basketball (100%)	Elite	① Macronutrient intake ② Micronutrient intake ⑤Alcohol consumption	3-day dietary record

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Table 1 (*continued*)

Author, year	Study type	Total sample	Athletes nationality	Mean age	Gender	Condition	Sport	Sport level	Domains assessed	Measurement tools
Duarte Junior, 2023[46]	Cross-sectional	30	Brazilian (100%)	28.1 (8.4)	M (73%) F (27%)	NR	Track&Field (40%) Para swimming (27%) Para powerlifting (20%) Para taekwondo (13%)	National and international	① Macronutrient intake ② Micronutrient intake ⑤Alcohol consumption	Validated FFQ
Hertig Godeschalk, 2023[47]	Observational Cohort	14	Swiss (100%)	34.0 (9.0)	M (43%) F (57%)	SCI (43%) Meningomyelocele (36%) MS (14%) Arthrogryposis (7%)	Para cycling (35%) Track&Field (22%) Tennis (22%) Basketball (7%) Badminton (7%) Shooting (7%)	Elite	① Macronutrient intake ⑥Low energy availability	3-day dietary record
Islamoglu, 2023[48]	Cross-sectional	40	Turkish (100%)	NR	M (90%) F (10%)	NR	Basketball (100%)	NR	① Macronutrient intake ② Micronutrient intake ③ Supplement use	24-h dietary recall
Myoenzono, 2023[49]	Cross-sectional	113	Japanese (100%)	35.99 (9.68)	M (74%) F (26%)	NR	NR	Elite	③ Supplement use ⑤Alcohol consumption	Non validated questionnaire
Sasaki, 2023[50]	Cross-sectional	101	Brazilian (100%)	18-60	M (81%) F (19%)	Paraplegia (26%) Cerebral and/or medullar palsy (21%) Limb deficiency (16%) Tetraplegia (9%) Polio (8%) Others (7%) Intellectual impairment (4%) Cerebrovascular accident (3%) Hemiplegia (2%) Malformation (2%) Plexus injury (2%)	Football (13%) Basketball (11%) Swimming (11%) Badminton (9%) Powerlifting (9%) Archery (8%) Track&Field (8%) Wheelchair rugby (8%) Wheelchair tennis (8%) Sitting volleyball (6%) Boccie (3%) Equestrianism (3%) Sailing (3%)	Regional, national and international	① Macronutrient intake ② Micronutrient intake ③ Supplement use ⑦ Dietary habits	2-day 24-h dietary recall
Vashishth, 2023[51]	Cross-sectional	13	Indian (100%)	20-50	NR	NR	Para swimming (100%)	NR	① Macronutrient intake ② Micronutrient intake ③ Supplement use ⑦ Dietary habits	Validated FFQ 24-h dietary recall
Kahvecioglu, 2024[52]	Cross-sectional	66	Turkish (100%)	27.5 (9.4)	M (76%) F (24%)	Limb deficiency (48.5%) Muscle strength and coordination disorders (18.2%) SCI (16.7%) Intellectual impairment (9.1%) Spina bifida (3%) Ataxia, short stature and intellectual impairment (1.5%)	Swimming (38%) Amputee football (30%) Wheelchair basketball (26%) Archery (6%)	NR	① Macronutrient intake ② Micronutrient intake ③ Supplement use ④ Hydratation status	24-h dietary recall
Shaw, 2024[53]	Cross-sectional	31	Canadian (33%) Australian (26%)	21-60	M (39%) F (61%)	NR	Para cycling (100%)	Elite (90%) Sub-elite (10%)	① Macronutrient intake ② Micronutrient intake	Validated FFQ

(*continued on next page*)

Table 1 (*continued*)

Author, year	Study type	Total sample	Athletes nationality	Mean age	Gender	Condition	Sport	Sport level	Domains assessed	Measurement tools
			USA (23%) British (6%) Belgian (4%) Irish (4%) South African (4%)						③ Supplement use ⑥Alcohol consumption ⑦ Dietary habits	
Weijer, 2024[54]	Cross-sectional	48	Dutch (81%) Norwegian (19%)	27.0 (23.0-33.0)	M (40%) F (60%)	SCI (35%) Limb deficiency (33%) Other (14%) Neurological disorder (9%) Visual impairment (9%)	Para cycling (27%) Wheelchair basketball (27%) Wheelchair tennis (21%) Para Nordic skiing (15%) Para Alpine skiing (10%)	Elite	① Macronutrient intake	3-day 24-h dietary recall

NR = Not Reported; M = Male; F = Female; nRCT = Non-Randomized Clinical Trial; MS = Multiple Sclerosis; SCI = Spinal Cord Injury; FFQ = Food Frequency Questionnaire; LEAF-Q = Low Energy Availability in Females Questionnaire; USG = Urine Specific Gravity.

provides a visual summary of the main findings stratified by impairment type, sport discipline, and competitive level, offering an overview of the heterogeneity in nutritional patterns across para-athlete subgroups.

The following subsections present a narrative summary of results for each domain, and detailed study-level data are available in Supplementary S4, which includes domain-specific tables summarizing the main findings of individual studies.

3.4.1. Macronutrient and fiber intake

Early investigations suggested diets high in carbohydrates and low in fat, comparable to able-bodied recommendations,[9,10] both conducted in wheelchair athletes with spinal cord injury. However, several subsequent studies in mixed cohorts of Paralympic athletes, including wheelchair basketball players, cyclists, and track athletes, noted intakes close to the lower recommended limits or below for carbohydrates, combined with higher fat intake than guidelines.[12,22,27,43,45,52]

Protein intake was frequently reported within recommended ranges. However, two studies, one in amputee footballers[13] and one in Brazilian para-athletes,[46] observed mean intakes exceeding recommended ranges, with values of 2.6–3.1 g/kg/day. Two studies, both in wheelchair athletes, reported mean intakes near the higher limits.[32,33] Furthermore, recent studies identified cases of insufficient protein intake among female athletes, with intakes below international recommendations.[43,52,37,47]

Fiber intake was generally below recommended values across cohorts, with inadequacies observed in both male and female athletes from different impairment groups and sports, including wheelchair users, track athletes, and mixed Paralympic samples.[32,15,16,36,53]

3.4.2. Micronutrient intake

Vitamin D consistently emerged as the most critical nutrient of concern. Multiple studies documented insufficient dietary intake and/or low serum 25(OH)D concentrations across different impairments and sports.[43,45,17,18,24,28,35,36,38,48,53]

Calcium and magnesium inadequacies were frequently reported, often in conjunction with low vitamin D intake.[12,43,52,17,28,39]

Iron intake was generally adequate for male athletes but deficiencies were common among women, with some studies also noting insufficient folate and zinc.[43,52,17,28,39]

Vitamin E was another nutrient frequently below recommended levels.[28,39,11]

Other vitamins and minerals demonstrated more variable patterns. Higher-than-recommended intakes were frequently observed for sodium, phosphorus, selenium, and several B vitamins, including niacin, riboflavin, B6, and B12,[43,36,39,23] whereas intakes of vitamin C, potassium, and pantothenic acid were often below recommended levels.[28,39,11]

3.4.3. Supplement use

The prevalence of supplement use among para-athletes varied widely across studies, ranging from 0% to over 90%. Some investigations reported no use at all, such as in amputee soccer players[13] and in a mixed Brazilian cohort.[50] Low prevalence (<25%) was observed in Indian para-swimmers,[51] Turkish national-level athletes with mixed impairments,[52] and U.S. wheelchair racers, where 22% consumed protein supplements.[8] Moderate prevalence (25–50%) was reported in Japanese and American wheelchair athletes,[9] international football tournaments involving athletes with cerebral palsy or visual impairments,[26] athletes with deafness,[29] and wheelchair basketball players.[48] Higher prevalence (51–75%) was documented in Japanese para-athletes, particularly for vitamin supplements,[10] in athletes with spinal cord injury,[17] and in mixed international wheelchair athletes,[20] with similar levels noted in Japanese Paralympic groups.[49] The highest prevalence (>75%) was found in wheelchair rugby players, where up to 91% of men and 78% of women reported regular use,[30] and in para-cyclists and triathletes, where 87% reported supplement intake[53]; a smaller study in national-level para-cyclists with SCI also reported

Table 2
Key findings and potential issues within each nutritional domain.

Nutritional domain	Key findings and potential issues in para-athletes
Macronutrients and fiber intake	Carbohydrate intake often below recommendations and fat intake above, especially in athletes with SCI and mixed cohorts. Protein intake generally adequate or high, but occasional insufficiency observed among female athletes. Fiber intake consistently low across all impairment types and sport disciplines. These imbalances may exacerbate metabolic risks such as insulin resistance, dyslipidemia, and early fatigue.
Micronutrients intake	Widespread deficiencies in vitamin D, calcium, magnesium, iron (particularly among female athletes), and vitamin E across impairment groups and sport disciplines. Intake above recommendations of sodium and B vitamins (niacin, riboflavin, B6, B12) commonly reported, suggesting potential nutrient imbalance. Vitamin D, calcium, and magnesium deficiencies raise particular concern due to their association with impaired bone health and muscle recovery. Iron and folate inadequacies more prevalent in female athletes, increasing risk of anemia and reduced performance.
Supplement use	Extremely variable prevalence of supplement use (from 0 to over 90%) across studies, with lowest rates in amputee and national-level athletes and highest in elite wheelchair rugby players, cyclists, and triathletes. Most frequently consumed supplements were vitamins and minerals, followed by creatine and omega-3 fatty acids. Sports food (e.g., drinks, gels, bars) were reported in only a few studies but showed moderate use (from 15 to 50%), suggesting similar prevalence to some traditional supplements. Vitamin D supplementation is particularly relevant given widespread deficiency and its key role in bone and muscle health. Emerging evidence supports creatine use in athletes with spinal cord injury, showing benefits for strength, lean mass, and functional capacity. Preclinical findings suggest potential anti-inflammatory and neuroprotective effects of omega-3 fatty acids, possibly beneficial for athletes with SCI or traumatic injuries.
Hydration status	Findings were mixed across studies, with both euhydration and hypohydration reported among para-athletes. Fluid intake was frequently below recommended levels, though some athletes reported deliberate attention to pre- and post-exercise hydration. Athletes with SCI are particularly vulnerable to fluid imbalance due to impaired thermoregulation, reduced sweating, and altered renal and hormonal regulation. Even mild dehydration may impair performance and increase risk of heat-related illness or secondary complications such as urinary dysfunction and kidney stones.
Alcohol consumption	Alcohol intake among para-athletes was highly variable across studies. Most cohorts—particularly those with SCI or in wheelchair basketball—reported low or negligible consumption. However, some subgroups (e.g., U.S., Italian, Swedish, and Japanese Paralympic athletes) showed high prevalence of alcohol use, with regular or weekly drinking. Excessive intake may impair muscle recovery, metabolic function, and exacerbate cardiometabolic risk, which is already elevated in individuals with SCI.
Low energy availability	Evidence limited but higher risk in women and endurance athletes. Potential consequences: RED-S, poor bone health, endocrine disruption.
Dietary habits	Limited and heterogeneous evidence. Meal frequency variable, some athletes skip meals or substitute snacks for dinner. Food group intake inconsistent: fruit and dairy intake variable, green leafy vegetables often low, whole grain, pulses, nuts/seeds intake limited.

SCI = Spinal Cord Injury; RED-S = Relative Energy Deficiency in Sport.

widespread use.[43]

The most frequently used products were vitamin and mineral supplements, followed by creatine and omega-3 fatty acids.

3.4.4. Hydration status

Studies assessing hydration status among para-athletes reported mixed findings, with evidence of both adequate and inadequate hydration. Using urine specific gravity (USG), a study found that the majority of athletes with intellectual disabilities were hypohydrated (21.7% significantly hypohydrated; 52.2% hypohydrated), while only 26.1% were classified as euhydrated. Compared to sedentary peers with intellectual disabilities, a lower proportion of athletes were euhydrated.[21] In contrast, another investigation reported that 10 of 12 wheelchair rugby players maintained euhydration (USG <1.020 g/ml) across both morning and afternoon training sessions, although blood sodium concentrations significantly declined over the course of the training day.[19]

Reported fluid intakes also varied substantially. A study, conducted in wheelchair basketball players with spinal cord injury, observed relatively low mean daily fluid intake (1016 mL/day),[22] whereas another study, examining a mixed sample of Paralympic athletes with physical impairments, found higher values (3222 ± 831 mL/day), although still below recommended levels, classifying most athletes as inadequately hydrated.[34] A recent study, in a cohort of athletes with different impairments competing at national and international levels, noted that 84.8% reported paying attention to fluid intake before and after training or competition, typically consuming 500–1000 mL of fluids before and after training.[52]

3.4.5. Alcohol consumption

Alcohol use among para-athletes showed marked variability across studies.

A study conducted in athletes with physical impairments from various sports, found that 60% abstained from alcohol, with the remainder averaging less than one drink per week.[10] Another study also observed near-complete abstinence in wheelchair basketball players with spinal cord injury.[22] More recent work in mixed cohorts of Brazilian[46] and international para-athletes[53] confirmed low average intakes (≈1.2 g/day), although about half of athletes reported occasional consumption.

A study in Swedish Paralympic athletes, reported that one-third consumed alcohol, averaging 12 g/day.[11] Hedrick et al., in U.S. wheelchair athletes, found that 75% drank alcohol more than once per week, with higher proportions among men.[8] Similarly, a study in Italian para-athletes, reported 87% prevalence, with mean intake of 4.1 g/day.[45] Myoenzono et al. observed that Paralympic athletes consumed alcohol on approximately one day per week, at a higher frequency than Olympic counterparts.[49]

3.4.6. Low energy availability

Evidence on LEA among para-athletes is limited and inconsistent.

A study in wheelchair athletes, found that none of the participants fell below the standard cutoff (<30 kcal kg^{-1} FFM·day^{-1}), although three presented with moderate energy availability, while the remainder achieved optimal values.[32] Similarly, an investigation conducted in a mixed cohort of male and female para-athletes, observed no cases of weekly LEA based on cutoffs for able-bodied athletes, though individual fluctuations were common, with some athletes experiencing LEA on isolated days.[40]

A study conducted in endurance-trained para-athletes, reported that female athletes presented with LEA on 73% of analyzed days compared to 30% in males.[37] Another study found that, in athletes with spinal cord injury across different lesion levels and sports, all participants

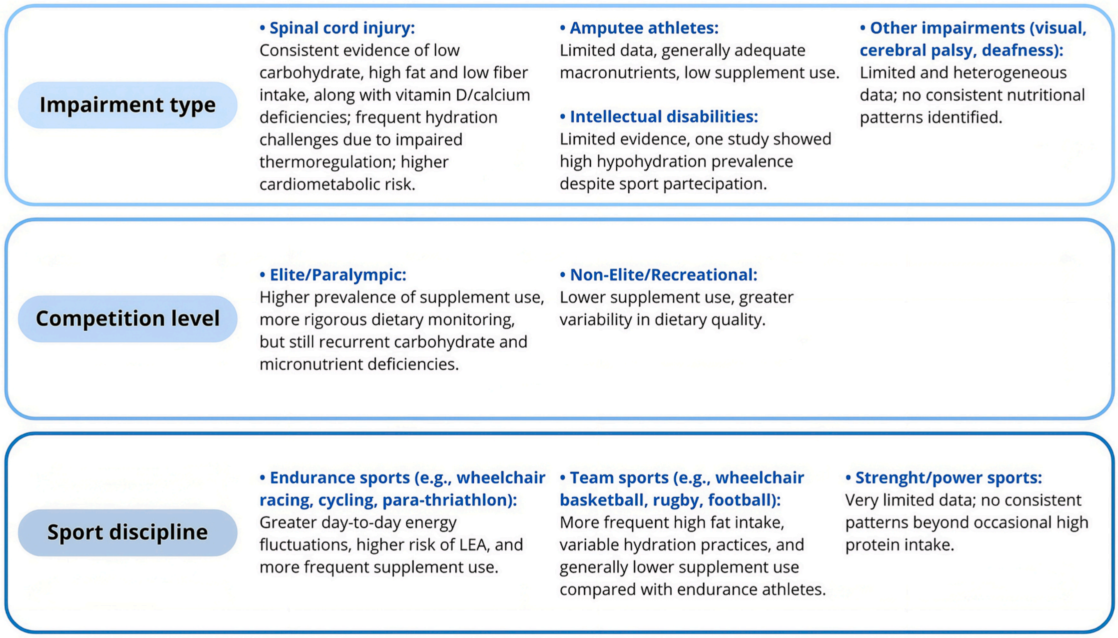

Fig. 4. Summary of main nutritional findings across para-athlete subgroups, stratified by impairment type, sport discipline, and competitive level. LEA = Low Energy Availability.

experienced at least one day of LEA, with comparable proportions of LEA days across sex, lesion level, and sport discipline.[47]

3.4.7. *Dietary habits*

Five studies assessed dietary habits in para-athletes, of which 1 examined dietary patterns, 2 assessed meal frequency, and 2 evaluated food groups consumption. The study reporting dietary practices found that 60.5% of athletes followed high-carbohydrate diets, 51.4% low-fat diets, 40.3% high-protein diets, 46.0% high-fiber diets, 16.2% practiced energy manipulation, and 8.9% avoided red meat.[10] Regarding meal frequency, one study observed 3.8–4.0 meals/day with minimal snack consumption,[27] while another study found most athletes consumed three main meals daily, often including a night snack after dinner or substituting dinner for a snack.[50] Food groups intake was heterogeneous: Vashishth et al. reported limited green leafy vegetable and protein intake, whereas fruit and dairy consumption was variable.[51] Shaw et al. found frequent consumption of grains, fruits, and vegetables (3.5, 2.9, and 4.2 times/day, respectively), though whole-grain intake was low (18%) and consumption of pulses, nuts, and seeds was limited.[53]

4. Discussion

4.1. *Macronutrient*

Macronutrient intake among para-athletes showed recurring imbalances with important clinical implications. Several studies reported carbohydrate intakes close to or below recommended levels, often accompanied by elevated fat intake, particularly in athletes with spinal cord injury and in mixed cohorts. Interestingly, a temporal pattern was observed across the literature with earlier studies conducted in the 1990s generally reported carbohydrate intakes within recommended ranges, whereas more recent studies (post 2000) more frequently documented suboptimal carbohydrate consumption. Although methodological differences between studies may contribute to this pattern, it may also reflect broader shifts in dietary trends within athletic populations, including the growing emphasis on higher protein intake. This pattern is noteworthy given the altered metabolic profile associated with SCI, including reduced muscle mass, impaired glycogen storage capacity, and a lower reliance on carbohydrate oxidation during exercise.[55] As a result, athletes with SCI may be at heightened risk of early fatigue and suboptimal recovery when carbohydrate intake is inadequate.[56] Beyond performance, these metabolic alterations have broader health consequences: several body composition and metabolic-associated disorders, such as glucose intolerance, insulin resistance, and lipid abnormalities, occur prematurely after SCI and at a higher prevalence compared to able-bodied populations. Within weeks to months of injury, a marked reduction in total lean mass, particularly in the lower extremities, is accompanied by increased fat mass and fat infiltration into intramuscular and visceral depots, changes strongly linked to abnormal metabolic profiles.[57] These alterations contribute to an elevated risk of cardiometabolic comorbidities, including type 2 diabetes and cardiovascular disease, which have been documented with higher prevalence among athletes with SCI.[58] Inadequate carbohydrate intake, particularly when coupled with high fat consumption, may further exacerbate these risks by promoting unfavourable lipid profiles and impaired glucose tolerance.

Although most robust data come from athletes with SCI, comparable macronutrient imbalances may have specific consequences in other impairment groups. In athletes with limb amputation, for example, post-amputation reductions in lean mass and an increased propensity to accumulate adipose tissue, together with altered locomotor energy cost, can magnify the metabolic consequences of low carbohydrate and high fat diets, increasing fatigue during higher-intensity efforts and raising long-term cardiometabolic risk.[59]

Similarly, athletes with cerebral palsy often present with lower resting energy expenditure, altered body composition and intramuscular fat infiltration; in these contexts, insufficient carbohydrate availability and low fibre/protein quality may exacerbate exercise intolerance, impair recovery and accelerate adverse metabolic changes.[60]

This underscores the dual importance of carbohydrate management in para-athletes, not only to sustain training and competition demands, but also as a cornerstone of preventive health care.

Fiber intake was consistently below recommended levels across cohorts, including both endurance and team-sport athletes. This finding may partially reflect the generally low intake of carbohydrate-rich foods such as whole grains, fruits, and vegetables, which represent major dietary sources of both fiber and essential micronutrients. This is of particular concern in SCI, where gastrointestinal dysmotility and microbiota alterations are common.[61] Low fiber intake may exacerbate these issues, further increasing the risk of secondary complications such as metabolic dysfunction and impaired immune function.

Protein intake was generally adequate or above international recommendations, supporting muscle maintenance and training adaptations. However, several studies reported insufficient intake among female para-athletes, raising concerns regarding low energy availability and compromised recovery.[62] This finding underscores the importance of sex-specific monitoring of protein intake in this population, where the physiological consequences of undernutrition may be amplified by sex-related factors.

Importantly, most studies contributing to macronutrient data were of good methodological quality and frequently used validated dietary assessment tools. This strengthens the confidence in the observed patterns of low carbohydrate intake, adequate-to-high protein intake (sometimes low in women), and fiber insufficiency. Nonetheless, the limited representation of certain impairment groups and sports restricts the generalizability of findings and underscores the need for more inclusive investigations.

Accurate assessment of macronutrient and micronutrient intake is essential for optimizing performance and long-term health in para-athletes. The most reliable methods, validated in athletic populations, include weighed or estimated food diaries, multiple 24-h dietary recalls, and food frequency questionnaires.[63] These tools allow detailed evaluation of habitual dietary intake, including energy, macronutrients, micronutrients, and supplements, while accounting for sport-specific variations in training and competition schedules. Routine application of these validated assessment methods provides the foundation for individualized nutritional planning and early identification of potential inadequacies.

4.2. Micronutrient

Micronutrient inadequacies emerged as a consistent and concerning theme across the reviewed literature. Multiple studies reported frequent deficiencies in vitamin D, calcium, magnesium, iron (particularly among female athletes), and vitamin E, nutrients vital to bone health, muscle function, and recovery.[64] Conversely, some micronutrients, such as sodium, phosphorus, selenium, and several B vitamins (e.g., niacin, riboflavin, B6, B12), were reported at intakes above recommended levels. However, because B vitamins are water-soluble and excess amounts are typically excreted in the urine, these findings more likely indicate high dietary intake rather than a true risk of toxicity.

Although most studies were rated as fair in methodological quality, there was substantial agreement across cohorts regarding common micronutrient deficiencies and excesses. Nevertheless, the consistency of findings across different populations suggests that these patterns are likely meaningful and can inform clinical considerations.

From a clinical standpoint, deficiencies in vitamin D and calcium pose a particular threat to para-athletes, especially in wheelchair users, who already face heightened risk of low bone mineral density and osteoporosis.[65] Practices such as targeted screening for vitamin D levels and considering supplementation should become routine in rehabilitation and sports medicine settings.

4.3. Supplement use

Supplement use among para-athletes was characterized by high variability, ranging from complete abstinence in some national-level or amputee cohorts to very high prevalence (>75%) in elite wheelchair rugby players, cyclists, and triathletes. Across the included studies, vitamin and mineral supplements were the products more consistently reported with higher prevalence, followed by creatine and omega-3 fatty acids. However, the classification of dietary supplements varied substantially across studies. In many cases, vitamins and minerals were reported as a single combined category and the specific types of micronutrients were not clearly defined; for example, only one study specifically assessed electrolyte supplements, whereas other studies reported “minerals” more generally, making it unclear whether electrolyte products were included. In addition, sport food such as sports drinks, gels, and bars were not consistently classified as dietary supplements. In the few studies that assessed these products, their reported prevalence ranged from approximately 15-50% for sports drinks and around 10-40% for bars and gels, suggesting their use may be comparable to that of other commonly reported supplements. This heterogeneity in definitions and reporting limits direct comparisons across studies and may partly explain the observed variation in supplement use patterns.

From a clinical perspective, vitamin D supplementation emerges as the most relevant, given the consistently high prevalence of deficiency and its critical role in bone and muscle health.[66]

Creatine supplementation shows promise for individuals with SCI, who often experience severe muscle deconditioning and reduced upper-body capacity. In a randomized crossover trial, 20 g/day of creatine improved VO_2, ventilatory threshold, and arm work capacity in patients with cervical SCI.[67] Similarly, low-dose creatine (3 g/day) combined with resistance training enhanced upper body strength and muscle cross-sectional area over 8 weeks.[68] Preclinical models further suggest neuroprotective effects with improved locomotor recovery.[69] Although evidence is limited, these findings indicate that creatine can augment training adaptations and functional performance in SCI, making it a potentially valuable adjunct for para-athletes, particularly those struggling to preserve muscle mass and strength. This may be especially relevant given the well-documented shift from oxidative type I to fast glycolytic type II fibers following spinal cord injury, which contributes to early fatigability and reduced muscular endurance.[70]

Evidence on omega-3 supplementation in para-athletes or individuals with disabilities is scarce, however, preclinical and limited clinical data indicate anti-inflammatory and neuroprotective effects, potentially relevant for athletes with SCI or traumatic brain injuries.[71] Considering their broader cardiovascular and metabolic benefits,[72] omega-3 supplementation may be particularly valuable in para-athletes, who face increased risk of cardiometabolic comorbidities.

To our knowledge, beyond SCI, no intervention-based studies evaluating supplement efficacy in athletes with other impairments (e.g., cerebral palsy, visual impairment, or limb deficiency) are currently available. The literature identified in this review therefore consist primarily of descriptive prevalence studies, leaving uncertainty regarding the benefits and risks in these populations. This gap highlights the need for future studies that evaluate both safety and effectiveness of supplements across diverse impairment types, in order to guide clinical decision-making and ensure athlete safety.

4.4. Hydration status

Athletes with SCI are particularly vulnerable to disturbances in fluid balance due to impaired thermoregulation, reduced sweating capacity, and altered renal and hormonal responses.[73] Even mild hypohydration in this group may contribute to performance decrements and heightened risk of heat-related illness.[74] In addition, inadequate hydration may exacerbate chronic issues such as urinary tract dysfunction, and kidney stone formation which are common secondary complications in SCI.[75] Behavioural and environmental factors may further contribute to hypohydration risk, as some para-athletes, especially those with an SCI, may deliberately restrict fluid intake due to concerns about limited access to accessible washroom facilities during training and competition.

From a clinical perspective, hydration assessment in para-athletes remains challenging, as traditional markers such as urine specific gravity or body mass changes may be confounded by autonomic dysfunction or altered sweating responses. Wearable technologies and novel biosensors may provide promising avenues for real-time monitoring of hydration and electrolyte balance,[76] though validation in para-athlete populations is still lacking.

Overall, the current evidence within this domain is limited in both quantity and quality. Most studies were rated as fair and relied on small sample sizes, reducing the certainty of observed patterns. Nevertheless, the combination of recurrent hypohydration reports and the known physiological vulnerabilities of para-athletes underscores the importance of individualized hydration strategies, particularly in SCI and endurance athletes. Clinicians working with this population should consider integrating basic hydration screening (e.g., self-reported fluid logs, urine color scales) and assessing fluid intake through dietary assessment tools as part of routine evaluations, with referral to sports nutrition specialists when recurrent issues are suspected.

4.5. Alcohol consumption

Overall, average alcohol intake across studies was generally low. However, the findings of some subgroups of high consume highlight that certain populations of para-athletes engage in relatively high alcohol use, which may carry implications for both performance and long-term health. Alcohol negatively affects muscle recovery, and metabolic function,[77] while also increasing the risk of comorbidities such as cardiovascular disease, already more prevalent among individuals with SCI.[78]

The strength of evidence in this domain is limited, as many studies were dated, conducted with small sample sizes, or rated as fair-to-poor quality. Therefore, while it is likely that alcohol consumption in para-athletes is heterogeneous, with most reporting low intake but some subgroups drinking at higher levels, the certainty of these findings remains modest.

4.6. Low energy availability

The findings about low energy availability align with broader observations in able-bodied athletes, where LEA is more common in women and endurance disciplines, contributing to impaired recovery, reduced performance, and increased risk of relative energy deficiency in sport (RED-S).[79] In para-athletes, the clinical implications may be even more pronounced, as reduced resting energy expenditure, altered body composition, and metabolic adaptations associated with SCI or other impairments complicate accurate estimation of energy requirements. This raise concerns that undetected or intermittent LEA may contribute to long-term complications such as poor bone health, endocrine disruption, and increased susceptibility to illness or injury.[80]

The strength of current evidence is limited by the small number of studies, most of which were rated as fair quality. As such, the certainty of conclusions remains low, making LEA an important grey area in para-sport nutrition research. Clinicians should nevertheless remain vigilant, particularly when working with female and endurance para-athletes, where risk appears greatest. Simple screening tools derived from able-bodied sport, such as low energy availability questionnaires[81] may help identify athletes at risk and guide timely referral to sports nutrition specialists.

4.7. Dietary habits

Beyond individual nutrient intake, only a few studies of moderate quality (one good, four fair) examined dietary habits among para-athletes. Overall, findings show heterogeneous dietary habits, with variable adherence to specific diets, inconsistent meal frequency, and uneven consumption of key food groups, including fruits, vegetables, and protein sources. Given the small number of studies and their descriptive nature, dietary behaviours remain an understudied yet potentially important factor for long-term health, nutritional adequacy, and performance in para-athletes, warranting further investigation in future research.

4.8. Limitations

Some limitations should be acknowledged. The search strategy may not have captured all studies involving certain impairment groups, particularly athletes with intellectual impairments (e.g., studies conducted in the contexts of the Special Olympics), amputation and visual impairment. In addition, variation in the definition and classification of dietary supplements across studies, including whether sport foods were considered supplements, may have influenced reported prevalence.

5. Conclusions

Para-athletes face unique nutritional challenges that require clinical awareness. Individualized interventions by sports dietitians are ideal but often unavailable, making multidisciplinary collaboration essential for tailored, evidence-based care.

From a public health perspective, early detection of inadequate intake, hydration issues, or risky supplement use is crucial to prevent long-term complications, including osteoporosis, cardiometabolic disease, and relative energy deficiency.

Future research should target under-studied impairment groups, account for sport, competition level, and sex, and report subgroup analyses. High-quality, standardized methods are needed to produce robust evidence to inform clinical practice and public health policy.

CRediT authorship contribution statement

Daniele Conte: Writing – original draft, Visualization, Methodology, Investigation, Conceptualization. **Annalisa Di Nucci:** Writing – review & editing, Investigation, Conceptualization. **Giuliana De Maio:** Writing – review & editing, Investigation, Conceptualization. **Maria Parpinel:** Writing – review & editing, Validation, Supervision, Conceptualization.

Ethics

As this was a scoping review, ethical approval was not necessary.

Data sharing

Data sharing does not apply to this article, as the scoping review used publicly available data.

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Declaration of competing interest

The authors have no conflict of interest to declare.

Appendix A. Supplementary data

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