mgr Daria Masztalerz-Kozubek

Związek między czynnikami żywieniowymi, środowiskowymi i socjodemograficznymi a rozwojem dzieci we wczesnym okresie ich życia

Associations between nutritional, environmental, and sociodemographic factors and early childhood development

Rozprawa doktorska na stopień doktora
w dziedzinie nauk medycznych i nauk o zdrowiu
w dyscyplinie nauki o zdrowiu
przedkładana Radzie Dyscypliny Nauk o Zdrowiu
Warszawskiego Uniwersytetu Medycznego

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Key words: early feeding; children; eating behaviors; dietary patterns; bone health

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1. **Masztalerz-Kozubek D.**, Zielinska-Pukos M.A., Hamulka J.: Early Feeding Factors and Eating Behaviors among Children Aged 1–3: A Cross-Sectional Study. Nutrients, 2022, 14, 2279. Doi: 10.3390/nu14112279

IF = 5,9 MNiSW = 140 pkt.

2. **Masztalerz-Kozubek D.**, Zielinska-Pukos M.A., Plichta M., Hamulka J.: The influence of early and current feeding practices, eating behaviors, and screen time on dietary patterns in Polish toddlers - a cross-sectional study. Appetite, 2024, 201, 107580. Doi: 10.1016/j.appet.2024.107580

IF = 3,8 MNiSW = 100 pkt.

3. **Masztalerz-Kozubek D.**, Zielinska-Pukos M.A., Hamulka J.: Sex-specific effects of a Mediterranean diet on lower limb bone strength in Polish children. Bone, 2024, 189, 117252. Doi: 10.1016/j.bone.2024.117252

IF = 3,6 MNiSW = 100 pkt.

Sumaryczny IF: 13,3 **MNiSW**: 340 pkt.

Spis treści

Wykaz stosowanych skrótów

BLW	metoda rozszerzania diety kierowana przez dziecko (ang. Baby-Led Weaning)
BMI	indeks masy ciała (ang. body mass index)
CAWI	wywiad wspomagany komputerowo (ang. Computer-Assisted Web Interview)
CEBQ	kwestionariusz zachowań żywieniowych dzieci (ang. Children's Eating Behavior Questionnaire)
CI	przedział ufności (ang. confidence interval)
DD	chęć picia (ang. desire to drink)
EF	radość z jedzenia (ang. enjoyment of food)
EOE	emocjonalne przejadanie się (ang. emotional overeating)
EU-27	Unia Europejska składająca się z 27 państw członkowskich (European Union and its current 27 member countries)
EUE	emocjonalne ograniczenie jedzenia (ang. emotional undereating)
FF	wybredność w jedzeniu (ang. food fussiness)
FFQ	kwestionariusz częstotliwości spożycia żywności (ang. food frequency questionnaire)
FR	reaktywność na jedzenie (ang. food responsiveness)
IQR	rozstęp międzykwartylowy (ang. interquartile range)
MVP-aMED score	zmodyfikowana polska wersja indeksu diety śródziemnomorskiej (ang. modified version of Polish-adapted Mediterranean diet score)
PKB	produkt krajowy brutto
Polish-aMED score	polska wersja indeksu diety śródziemnomorskiej (ang. Polish-adapted Mediterranean diet score)
QUS	ilościowa ultradźwiękowa ocena kości (ang. quantitative ultrasound)
SD	odchylenie standardowe (ang. standard deviation)
SE	powolne jedzenie (ang. slowness in eating)
SR	reaktywność na sytość (ang. satiety responsiveness)
WHO	Światowa Organizacja Zdrowia (ang. World Health Organization)

Streszczenie w języku polskim

Intensywny rozwój dziecka oraz jego zdrowie w pierwszych latach życia są warunkowane przez szereg wzajemnie współoddziałujących czynników żywieniowych oraz związanych ze stylem życia. Identyfikacja determinantów korzystnych zachowań czy nawyków żywieniowych oraz innych czynników związanych ze zdrowiem dzieci (np. jakość kośćca) może być istotnym elementem przyczyniającym się do poprawy zdrowia publicznego. W literaturze niewiele jest natomiast badań analizujących jednoczesny wpływ w/w czynników.

Celem pracy była ocena zależności pomiędzy wczesnymi czynnikami żywieniowymi, środowiskowymi i socjodemograficznymi a rozwojem dzieci w wieku 1-7 lat. Badanie składało się z dwóch etapów i zostało zrealizowane w latach 2020-2023. Etap I – badanie ankietowe, zostało przeprowadzone z wykorzystaniem wspomaganego komputerowo wywiadu (CAWI) i objęło 467 matek dzieci w wieku 1-3 lata. Kwestionariusz ankiety zawierał pytania dotyczące m.in. początkowego i aktualnego żywienia dziecka oraz kwestionariusz CEBQ (Children's Eating Behavior Questionnaire). Etap II składał się z badania ankietowego oraz oceny jakości kośćca i wzięło w nim udział 205 dzieci w wieku 3-7 lat wraz z rodzicami. Dane z FFQ pozwoliły na obliczenie indeksu diety śródziemnomorskiej w wersji zmodyfikowanej – MVP-aMED. Ocena jakości kośćca została przeprowadzona metodą badania ultradźwiękowego (Quantitative Ultrasound – QUS) przy użyciu urządzenia Sunlight Omnisense 9000 (BeamMed, Izrael). Metodą k-średnich wyodrębniono wzory żywieniowe – związane z wczesnym żywieniem, rodzajem produktów uzupełniających i sposobem spożywania posiłków.

W etapie I wykazano, iż dłuższy czas karmienia piersią był negatywnie związany z podskalami: radość z jedzenia (EF) oraz chęć picia (DD), a pozytywnie związany z reaktywnością na sytość (SR) i powolnym jedzeniem (SE). Ponadto częstsze podawanie domowych posiłków uzupełniających w porównaniu z komercyjnymi może wiązać się z wyższym poziomem SR. Rozpraszający sposób spożywania posiłków był negatywnie związany z EF, a pozytywnie z podskalami DD i SE. Czynniki takie jak wyższy wynik w podskali EF i SR zwiększały szanse na przynależność do prozdrowotnego wzoru żywieniowego, a komercyjny wzór żywienia uzupełniającego, rozpraszający sposób spożywania posiłków, wyższy wynik w podskali wybredność w jedzeniu (FF) oraz czas spędzony przed ekranem zmniejszały te szanse. Rozpraszający sposób spożywania posiłków w pierwszych 3 miesiącach rozszerzania diety oraz osobny w ostatnich 3 miesiącach żywienia, jak również wyższy wynik w podskali FF zwiększały szanse na przejawianie wzoru wybiórczego, podczas gdy komercyjny wzór żywienia uzupełniającego, brak obecnego karmienia piersią oraz czas spędzony przed ekranem zwiększały szanse na przynależność do przetworzonego wzoru żywieniowego.

W etapie II u dziewcząt wykazano różnice między wynikiem indeksu MVP-aMED i wskaźnikiem BMI z-score a QUS z-score. Dziewczynki, których dieta charakteryzowała się większym przystosowaniem do diety śródziemnomorskiej, miały wyższy wynik QUS z-score,

świadczący o lepszej jakości kośćca. Z kolei dziewczynki, które miały nadwagę lub otyłość, miały niższy wynik QUS z-score, w porównaniu do tych z prawidłową masą ciała. W modelu wieloczynnikowym potwierdzona została zależność jedynie z dietą śródziemnomorską.

Na podstawie uzyskanych wyników stwierdzono, iż wybrane praktyki żywieniowe (m.in. dłuższe karmienie piersią, oferowanie domowych produktów podczas rozszerzania diety, częstsze wspólne posiłki, elementy diety śródziemnomorskiej) oraz ograniczanie czasu spędzanego przez dzieci przed ekranem mogą być szczególnie istotne w kontekście kształtowania korzystnych zachowań żywieniowych, prozdrowotnych wzorów żywieniowych czy lepszej jakości kośćca. W związku z powyższym należy zwrócić uwagę na te aspekty w edukacji żywieniowej rodziców małych dzieci.

Wyniki niniejszego badania mogą znaleźć zastosowanie w edukacji i poradnictwie żywieniowym, zarówno rodziców jak i dzieci. Ponadto mogą sugerować kierunek dalszych długoterminowych badań oceniających wpływ analizowanych czynników na rozwój i zdrowie dzieci.

Streszczenie w języku angielskim

Title: Associations between nutritional, environmental, and sociodemographic factors and early childhood development

The rapid development of a child and their health during the first years of life are determined by a range of mutually interacting nutritional and lifestyle factors. Identifying the determinants of desirable eating behaviors or habits, as well as other factors related to children's health (e.g., bone quality), may constitute an important element contributing to public health improvement. However, the literature contains few studies analyzing the simultaneous impact of these factors.

The aim of this study was to assess the relationships between early nutritional, environmental, and sociodemographic factors and the development of children aged 1–7 years. The study was conducted in two stages between 2020 and 2023. Stage I – a survey study – was carried out using a computer-assisted web interview (CAWI) and included 467 mothers of children aged 1–3 years. The questionnaire included questions on, among other things, the child's early and current feeding and the Children's Eating Behavior Questionnaire (CEBQ). Stage II consisted of a survey and an assessment of bone quality and involved 205 children aged 3–7 years along with their parents. Data from the FFQ allowed the calculation of the Polish-adapted Mediterranean diet score in a modified version – MVP-aMED. Bone quality was assessed using quantitative ultrasound (QUS) with the Sunlight Omnisense 9000 device (BeamMed, Israel). Dietary patterns were identified using the k-means method, based on early feeding, types of complementary foods, and mealtime behaviors.

In Stage I, it was shown that longer breastfeeding duration was negatively associated with the subscales enjoyment of food (EF) and desire to drink (DD) and positively associated with satiety responsiveness (SR) and slowness in eating (SE). Additionally, more frequent provision of homemade complementary foods compared to commercial ones was associated with higher SR levels. Distracted mealtime environment pattern was negatively associated with EF and positively with DD and SE subscales. Factors such as higher EF and SR scores increased the odds of following a prohealth dietary pattern, whereas a commercial complementary foods pattern, distracted mealtime environment pattern, higher food fussiness (FF) scores, and screen time reduced these odds. Distracted mealtime environment pattern during the first three months of complementary feeding and separated mealtime environment pattern in the last three months, as well as higher FF scores, increased the odds of a non-eaters dietary pattern, while commercial complementary foods pattern, lack of current breastfeeding, and screen time increased the odds of belonging to a processed dietary pattern.

In Stage II, among girls, differences were observed between the MVP-aMED score and BMI z-score in relation to QUS z-score. Girls whose diet was more aligned with the Mediterranean diet had higher QUS z-scores, indicating better bone quality. Conversely, girls who were

overweight or obese had lower QUS z-scores compared to those with normal body weight. In the multivariate model, only the Mediterranean diet remained significant.

Based on these results, it was concluded that selected feeding practices (e.g., longer breastfeeding, offering homemade foods during complementary feeding, more frequent family meals, elements of the Mediterranean diet) and limiting children's screen time may be particularly important for creating desirable eating behaviors, prohealth dietary patterns, and better bone quality. Therefore, attention should be paid to these aspects in parental nutrition education for young children.

The results of this study may be applied in nutritional education and counseling for both parents and children. Furthermore, they may suggest directions for future long-term studies assessing the impact of the analyzed factors on children's development and health.

1. Wstęp

Żywienie dziecka we wczesnym okresie życia ma znaczący wpływ na jego rozwój i zdrowie w kolejnych latach. Ma to szczególne znaczenie obecnie, zważywszy na rosnącą częstość występowania niezakaźnych chorób dietozależnych. W Polsce nadmierną masę ciała (w tym otyłość) stwierdzono u blisko 20% dzieci w wieku przedszkolnym (Sawicki i wsp., 2025), a wśród starszych dzieci w wieku 7-9 lat odsetek ten wynosi ponad 30% (WHO COSI, 2025). Zasadne wydaje się więc zwrócenie uwagi na czynniki stylu życia oddziałujące w początkowym okresie, które mogą zmniejszać ryzyko występowania chorób takich jak otyłość, cukrzyca czy nadciśnienie tętnicze, również w wieku dorosłym. Styl życia, w tym zbilansowana dieta, pokrywająca zapotrzebowanie dziecka, jest jednym z determinantów optymalnego wzrostu i rozwoju, które w okresie wczesnego dzieciństwa przebiegają bardzo intensywnie. W tym czasie kształtują się także nawyki żywieniowe, na które wpływają zarówno czynniki osobnicze (uwarunkowania genetyczne, wiek, płeć) jak i środowiskowe (rodzina, rówieśnicy). Dzieci rozwijają wówczas swoje preferencje i zachowania żywieniowe poprzez bezpośrednią ekspozycję na żywność – jej smak, zapach, teksturę, kolory, a także w wyniku obserwacji środowiska rodzinnego, np. atmosfery podczas spożywania posiłków. Wymienione czynniki kształtują wzory żywieniowe dzieci, które współoddziałują z ich zachowaniami żywieniowymi, również w późniejszym okresie życia.

Prawidłowe żywienie jest również powiązane z jakością kośćca. Jak wynika z dokonanego przeglądu literatury, dieta matki, jej stan odżywienia, jak również urodzeniowa masa czy długość ciała dziecka, mogą mieć związek z rozwojem kości (Masztalerz-Kozubek i wsp., 2021). Wnioski z dostępnych badań są jednak niejednoznaczne, co może wynikać z różnego wieku dzieci w momencie przeprowadzania pomiarów, odmiennej metodologii badań jak również analizowanych czynników żywieniowych, tj. karmienie piersią wyłączne/niewyłączne, długość karmienia wyłącznego/jakiegokolwiek, pojedyncze czynniki żywieniowe lub grupy produktów vs. wzory żywienia (McGartland i wsp., 2004; Wosje i wsp., 2010; Mølgaard i wsp., 2011; Pirilä i wsp., 2011; Fewtrell i wsp., 2013; Kühn i wsp., 2014; Muniz i wsp., 2015; Blanco i wsp., 2017; Shin i wsp., 2017; Wallace i wsp., 2021; Liao i wsp., 2022; Rizzoli, 2022). W dostępnej literaturze niewiele jest także badań dotyczących wpływu innych czynników związanych z wczesnym żywieniem, jak chociażby rozszerzania diety, na rozwój kośćca u dzieci.

Pomimo licznych doniesień wskazujących na pozytywny wpływ prawidłowego żywienia w pierwszych latach życia na rozwój i zdrowie dziecka, sposób żywienia małych dzieci charakteryzuje się wieloma nieprawidłowościami. W badaniu Weker i wsp. (Weker i wsp., 2017) w ramach projektu PITNUTS autorzy przeanalizowali żywienie dzieci w wieku 5- 36 miesięcy i wskazali błędy, takie jak: zbyt wczesne rozszerzanie diety, wysokie spożycie cukrów prostych, a niskie mleka i mlecznych produktów fermentowanych, warzyw oraz owoców. W kolejnej edycji projektu, mimo iż wykazano pewne korzystne zmiany w żywieniu dzieci, takie jak wyższy odsetek dzieci karmionych piersią czy prawidłowe wprowadzanie żywności uzupełniającej, autorzy wciąż podkreślają problemy, jakim są zbyt niskie spożycie warzyw, ryb, olejów roślinnych, nasion roślin strączkowych, witaminy D, wapnia i błonnika jak również zbyt wysokie spożycie białka (Weker i wsp., 2024; Sawicki i wsp., 2025). Z kolei w badaniach własnych wykazano, że ponad 25% dzieci w wieku 12-24 miesiące otrzymywało posiłki z dodatkiem soli i cukru, przy czym u dzieci w wieku 24-36 miesięcy odsetek ten wynosił ponad 50% (Masztalerz-Kozubek i wsp., 2020). Coraz większą uwagę zwraca się także na pozażywieniowe czynniki stylu życia w kontekście kształtowania sposobu żywienia. Zważywszy na rosnącą powszechność i dostęp do urządzeń mobilnych, niepokojące są również dane dotyczące zależności między korzystaniem z ekranów a niekorzystnymi nawykami żywieniowymi, jak niższe spożycie warzyw, owoców i wyższe spożycie żywności przetworzonej, w tym słodzonych napojów czy słodyczy (Borghese i wsp., 2014; Shqair i wsp., 2019; Tambalis i wsp., 2020).

Biorąc pod uwagę przytoczone dane oraz luki w dostępnej literaturze naukowej, niezwykle istotnym było przeprowadzenie ogólnopolskiego badania, które pozwoliło kompleksowo ocenić czynniki żywieniowe, wybrane elementy stylu życia i jakość kośćca małych dzieci oraz wskazać najistotniejsze aspekty, które mogą się przyczynić do poprawy zdrowia małych dzieci.

2. Cel, zakres pracy i hipotezy badawcze

Celem głównym pracy było określenie zależności między wybranymi czynnikami żywieniowymi (m.in. długością karmienia piersią, rozszerzaniem diety, indeksem diety śródziemnomorskiej), socjodemograficznymi (wiekiem, poziomem edukacji matki, regionem zamieszkania) i środowiskowymi (czasem spędzanym przed ekranem), a rozwojem dzieci w wieku 1-7 lat. W ramach realizacji celu głównego przeprowadzono dwuetapowe badanie, uwzględniające cele szczegółowe zgodnie z ryc.1.

<table>
<tr><th></th><th>Badanie I</th><th colspan="2">Badanie II</th></tr>
<tr><td rowspan="2">Badanie</td><td rowspan="2">Ogólnopolskie badanie ankietowe na temat żywienia dzieci w wieku 1-3 lata przeprowadzone w latach 2020-2022 w grupie ich matek.</td><td colspan="2">Badanie przeprowadzone w przedszkolach na terenie Kielc i Warszawy w latach 2021-2023 z udziałem rodziców i dzieci w wieku 3-7 lat.</td></tr>
<tr><td>Badanie ankietowe wśród rodziców dzieci</td><td>Pomiary antropometryczne i ocena jakości kośćca u dzieci</td></tr>
<tr><td>Cel</td><td>Ocena zależności pomiędzy wczesnymi czynnikami żywieniowymi a rozwojem zachowań żywieniowych dzieci w wieku 1-3 lata.

Ocena zależności pomiędzy wczesnymi czynnikami żywieniowymi i elementami stylu życia a wzorami żywieniowymi.</td><td colspan="2">Ocena związku pomiędzy czynnikami żywieniowymi i antropometrycznymi a jakością kośćca u dzieci w wieku 3-7 lat.</td></tr>
<tr><td>Publikacje</td><td>✓ Publikacja 1 - Early feeding factors and eating behaviors among children aged 1–3: A cross-sectional study

✓ Publikacja 2 - The influence of early and current feeding practices, eating behaviors, and screen time on dietary patterns in Polish toddlers - A cross-sectional study</td><td colspan="2">✓ Publikacja 3 - Sex-specific effects of a Mediterranean diet on lower limb bone strength in Polish children</td></tr>
</table>

Ryc. 1. Przebieg badania.

Zakres pracy obejmował:

a. Etap I – badanie ankietowe wśród rodziców dzieci w wieku 1-3 lata:
   - opracowanie narzędzi badawczych, w tym kwestionariusza ankiety,
   - przeprowadzenie badania pilotażowego w celu weryfikacji kwestionariusza,
   - przeprowadzenie badania właściwego za pośrednictwem forów internetowych zrzeszających rodziców z całej Polski,
   - analizę uzyskanych wyników w kontekście określenia zależności między wybranymi czynnikami żywieniowymi, środowiskowymi i socjodemograficznymi a zachowaniami żywieniowymi i wzorami żywieniowymi wśród dzieci w wieku 1-3 lata.

b. Etap II – badanie zrealizowane wśród dzieci przedszkolnych w wieku 3-7 lat oraz ich rodziców w dwóch wybranych miejscowościach (Warszawa i Kielce):
   - rekrutację przedszkoli, pozyskanie zgód od rodziców na włączenie dziecka do badania oraz ich zakwalifikowanie na podstawie kryteriów włączenia i wyłączenia,
   - przeprowadzenie pomiarów antropometrycznych (masa i wysokość ciała) oraz jakości kośćca wśród z dzieci w przedszkolach,
   - przeprowadzenie badania ankietowego wśród rodziców dzieci biorących udział w badaniu oraz analizę uzyskanych danych,
   - analizę statystyczną uzyskanych wyników w celu określenia zależności między wybranymi czynnikami żywieniowymi, środowiskowymi i antropometrycznymi a jakością kośćca.

W pracy postawiono następujące hipotezy badawcze:

H1: Sposób żywienia w okresie niemowlęcym wpływa na zachowania żywieniowe u małych dzieci.

H2: Wczesne i aktualne czynniki żywieniowe (karmienie piersią, rozszerzanie diety, sposób spożywania posiłków), zachowania żywieniowe oraz czas spędzany przed ekranem mają związek ze wzorami żywieniowymi u małych dzieci.

H3: Wczesne i aktualne czynniki żywieniowe (karmienie piersią, rozszerzanie diety, spożycie wybranych grup produktów spożywczych, suplementacja witaminy D), jak również wskaźniki antropometryczne mają związek z jakością kośćca u dzieci w wieku przedszkolnym.

3. Materiał i metody badawcze

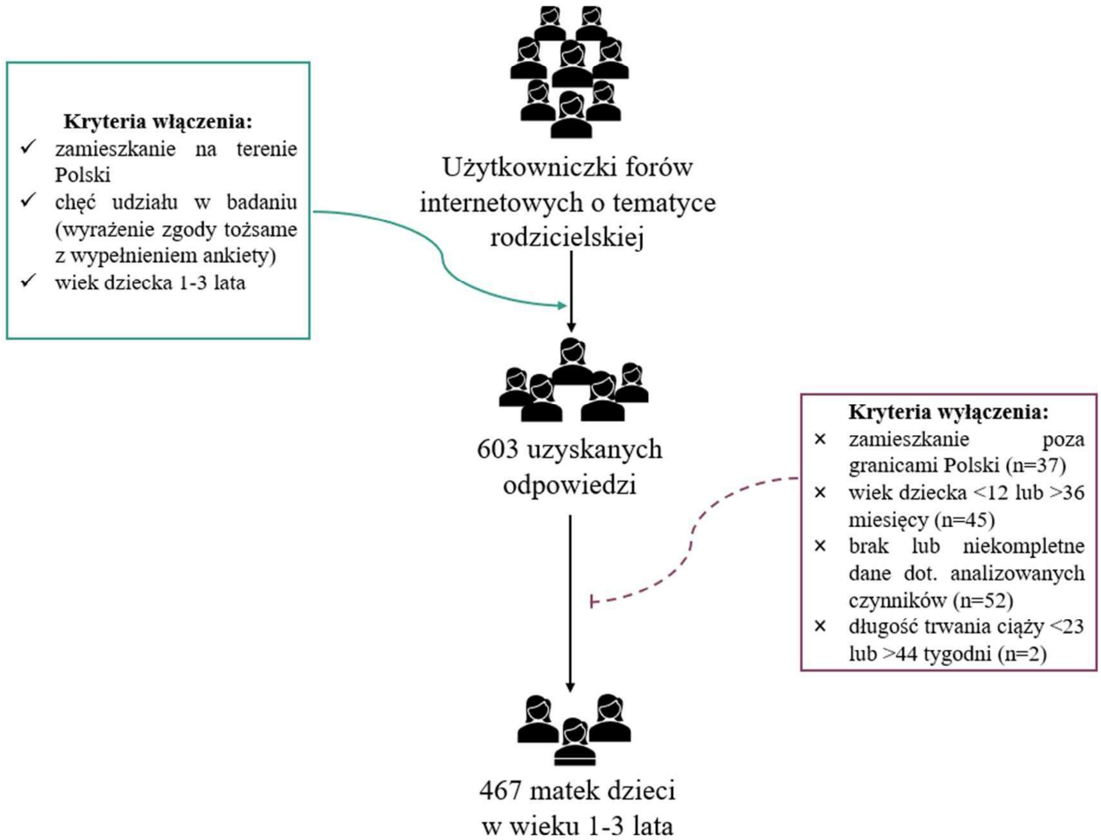
Na realizację badania naukowego uzyskano zgodę Komisji Etyki Badań Naukowych z Udziałem Ludzi przy Wydziale Nauk o Żywieniu Człowieka i Konsumpcji SGGW (nr uchwały 45p/2019). Badanie zostało przeprowadzone zgodnie ze standardami etycznymi określonymi w Deklaracji Helsińskiej. Pisemna zgoda na udział dziecka w badaniu została uzyskana od rodzica lub opiekuna prawnego przed włączeniem do badania.

Badanie obejmowało dwa etapy, które były realizowane jednocześnie (ryc. 1).

3.1 Etap I

Grupa badana

Badanie przeprowadzono w okresie grudzień 2020 – luty 2022, wśród użytkowników forów internetowych zrzeszających rodziców z całej Polski. Kwestionariusz ankiety został wypełniony przez 603 matki. Schemat doboru grupy badanej oraz kryteria włączenia i wyłączenia przedstawiono na ryc. 2. Po zastosowaniu kryteriów włączenia i wyłączenia do ostatecznej analizy włączono odpowiedzi od 467 respondentek.



Ryc. 2. Schemat doboru próby oraz kryteria włączenia i wyłączenia - etap I.

Metodyka badawcza

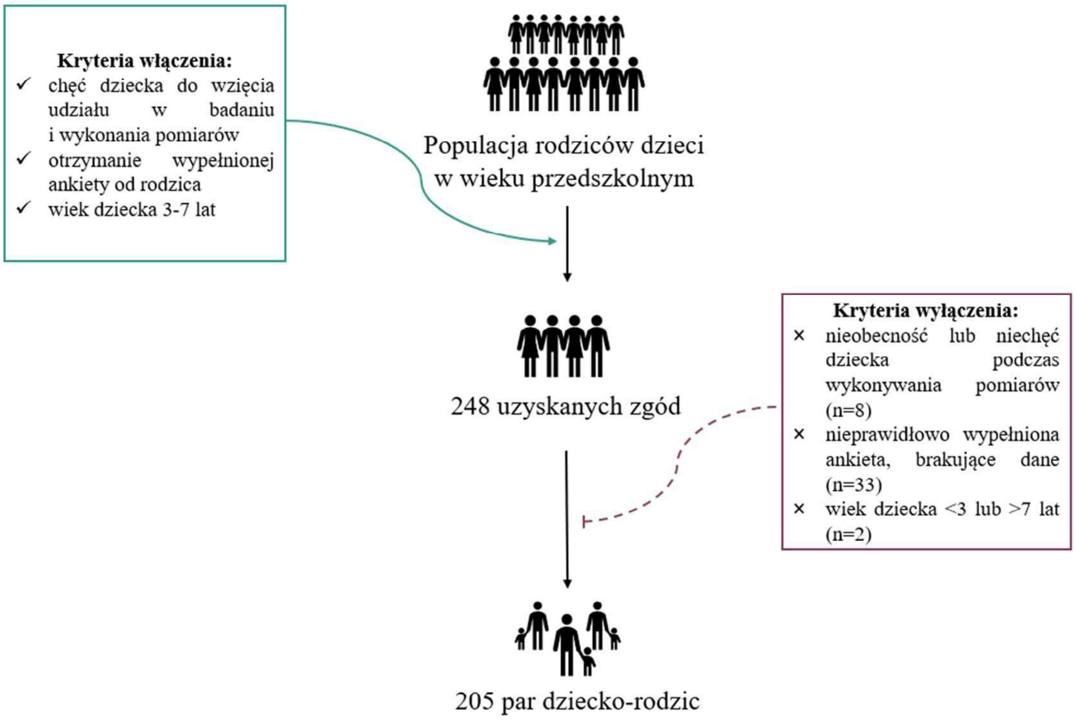
Kwestionariusz składał się z następujących części: (1) żywienie początkowe dziecka, (2) aktualne żywienie dziecka (w tym kwestionariusz częstotliwości spożycia, FFQ), (3) zachowania żywieniowe dziecka (kwestionariusz Children's Eating Behavior Questionnaire, CEBQ), (4) rozwój i zdrowie dziecka, (5) dane socjodemograficzne. Szczegółowy opis poszczególnych części kwestionariusza znajduje się w publikacji 1.

Ocenę zachowań żywieniowych dziecka przeprowadzono z wykorzystaniem polskiej wersji kwestionariusza CEBQ (Czepczor-Bernat & Brytek-Matera, 2019). Ze względu na potrzebę zastosowania kwestionariusza w młodszej grupie wiekowej, przeprowadzono jego walidację, co dodatkowo zostało zawarte w publikacji nr 2.

3.2 Etap II

Grupa badana

Badanie zostało przeprowadzone od października 2021 do czerwca 2023 roku, w dwóch miastach w Polsce o zróżnicowanym PKB – Kielcach (51-100% EU-27) oraz Warszawie (101-130% EU-27). Schemat doboru grupy badanej w etapie II oraz kryteria włączenia i wyłączenia przedstawia ryc. 3. Po weryfikacji kryteriów włączenia i wyłączenia, do ostatecznego opracowania wyników przeanalizowano dane od 205 dzieci i ich rodziców.



Ryc. 3. Schemat doboru próby oraz kryteria włączenia i wyłączenia - etap II.

Metodyka badawcza

Udział w badaniu obejmował wypełnienie kwestionariusza ankiety przez rodzica/opiekuna i wykonanie pomiarów antropometrycznych oraz jakości kośćca podczas pobytu dziecka w przedszkolu. Szczegółowe informacje przedstawiono w publikacji 3.

Kwestionariusz ankiety

Kwestionariusz ankiety zawierał pytania dotyczące wczesnego (w tym karmienia piersią i rozszerzania diety) oraz aktualnego (w tym kwestionariusz FFQ) żywienia, danych antropometrycznych (masa i długość ciała urodzeniowa oraz aktualna masa i wysokość ciała), przebiegu ciąży i zdrowia dziecka oraz danych socjodemograficznych.

Na podstawie danych o aktualnym sposobie żywienia dziecka obliczono zmodyfikowaną wersję indeksu diety śródziemnomorskiej MVP-aMED na podstawie Polish-aMED (Krusinska i wsp., 2018). Indeks wyliczono na podstawie mediany krotności spożycia dziewięciu grup produktów: warzyw, świeżych owoców, produktów zbożowych, ryb, roślin strączkowych, orzechów i nasion, olejów roślinnych, mleka i produktów mlecznych oraz mięsa czerwonego i przetworzonego.

Pomiary antropometryczne

Podczas wizyty w przedszkolu przeprowadzono pomiar masy i wysokości ciała dzieci. Masa ciała mierzona była z dokładnością do 0,1 kg za pomocą elektronicznej wagi cyfrowej (model 899 SECA, Hamburg, Niemcy), a wysokość ciała z dokładnością do 0,1 cm za pomocą stadiometru (model 213 SECA, Hamburg, Niemcy). Korzystając z kalkulatora WHO Anthro Survey Analyser (WHO Anthro Survey Analyser), na podstawie powyższych danych obliczono wskaźniki BMI z-score. Zgodnie z punktami odcięcia wskaźnika WHO BMI z-score (Anderson i wsp., 2017), populacja została sklasyfikowana na trzy grupy: prawidłowa masa ciała (BMI z-score -1,6–1), ryzyko nadwagi (BMI z-score 1,01–2,00) i nadwaga i otyłość (BMI z-score > 2,00).

Pomiar jakości kośćca

Ocena jakości kośćca została przeprowadzona metodą badania ultradźwiękowego (Quantitative Ultrasound – QUS) przy użyciu urządzenia Sunlight Omnisense 9000 (BeamMed, Izrael). Pomiarów dokonano w środkowej części kości piszczelowej (po stronie dominującej). Średnia z kilku (minimum 3) pomiarów porównywana jest z bazą referencyjną. Wynik jest wyrażony w metrach na sekundę (m/s), percentylach i z-score odpowiadających wiekowi i płci. Zastosowana do oceny jakości kośćca technika ultradźwiękowa jest bezpieczna, łatwa w użyciu, a fakt, iż urządzenia te są przenośne daje możliwość prowadzenia badań w terenie i w miejscach dogodnych dla małych dzieci. Pomiary zajmują tylko kilka minut i są pozbawione promieniowania, co sprawia, że są szczególnie przydatne do oceny jakości kośćca u dzieci.

4. Analiza statystyczna

Dane jakościowe przedstawiono w postaci liczebności i rozkładu procentowego, a ilościowe jako średnia ± odchylenie standardowe (SD) lub mediana i rozstęp międzykwartylowy (IQR). W pracy wykorzystano następujące metody i testy statystyczne:

- test Chi^2 do oceny istotności różnic zmiennych jakościowych pomiędzy grupami (publikacja 2, 3),
- test Kołmogorowa-Smirnowa (publikacja 1) lub Shapiro-Wilka (publikacja 2, 3) do weryfikacji rozkładu zmiennych ilościowych,
- testy U Manna-Whitneya, ANOVA Kruskala-Wallisa z testem post-hoc lub *t* Studenta do oceny istotności różnic zmiennych ilościowych pomiędzy grupami (publikacja 1, 2, 3),
- metoda k-średnich do wyodrębnienia wzorów żywieniowych (publikacje 1, 2, 3),
- regresja liniowa do oceny związku między wczesnymi czynnikami żywieniowymi a zachowaniami żywieniowymi (publikacja 1) oraz związku

między wczesnym i aktualnym żywieniem, parametrami antropometrycznymi i suplementacją witaminy D a jakością kośćca u dzieci w wieku 3-7 lat (publikacja 3),

- regresja logistyczna do analizy związku między wczesnymi i aktualnymi praktykami żywieniowymi, zachowaniami żywieniowymi i czasem spędzanym przed ekranem a wzorami żywieniowymi (publikacja 2).

Analizy statystyczne zostały przeprowadzone w programie STATISTICA 13.3 (StatSoft Inc., Tulsa, OK, USA; StatSoft, Kraków, Polska), a za istotny przyjęto poziom $\alpha \leq 0.05$.

5. Syntetyczne omówienie wyników badań i weryfikacja hipotez badawczych

Hipoteza 1: Sposób żywienia w okresie niemowlęcym wpływa na zachowania żywieniowe u małych dzieci.

Publikacja 1: Masztalerz-Kozubek D., Zielinska-Pukos M.A., Hamulka J.: Early Feeding Factors and Eating Behaviors among Children Aged 1–3: A Cross-Sectional Study. Nutrients, 2022, 14, 2279. Doi: 10.3390/nu14112279

Zdefiniowano trzy wzory wczesnego żywienia: (1) dłuższe karmienie piersią, w którym dzieci były karmione piersią w momencie badania, długość wyłącznego karmienia piersią wynosiła średnio 4,1 ± 2,4 miesiąca, a produkty uzupełniające wprowadzanie były w wieku 5.6 ± 0.9 miesiąca, (2) mieszanka mlekozastępcza, z krótkim okresem wyłącznego karmienia piersią (0,3 ± 0,7 miesiąca), brakiem obecnego karmienia piersią i wprowadzaniem pokarmów uzupełniających w wieku 4,3 ± 1,9 miesiąca, oraz (3) dłuższe wyłączne karmienie piersią, w którym dzieci nie były aktualnie karmione piersią, ale długość wyłącznego karmienia była najdłuższa i wynosiła 5,4 ± 0,9 miesiąca, a produkty uzupełniające wprowadzane były w wieku 5,6 ± 0,9 miesiąca. Do wyżej opisanych wzorów przynależało odpowiednio 37,1%, 34,3% i 28,5% dzieci.

Na podstawie informacji dot. rodzaju oferowanych produktów uzupełniających, wyodrębniono dwa wzory żywieniowe: (1) domowy, charakteryzujący się częstszym spożywaniem potraw, które jadła cała rodzina, ale dostosowanych do dziecka oraz gotowanych specjalnie dla dziecka; (2) komercyjny, charakteryzujący się częstszym spożywaniem produktów przeznaczonych dla dzieci (obiadki, zupy, deserki owocowe, kaszki i kleiki). Nieco ponad połowa dzieci przejawiała wzór domowy (55%).

Zdefiniowano trzy wzory spożywania posiłków podczas rozszerzania diety: (1) rozpraszający, w którym dzieci częściej jadły podczas zabawy, oglądania telewizji, były rozpraszane przez rodziców; (2) osobny, charakteryzujący się częstszym spożywaniem posiłków osobno niż inni członkowie rodziny oraz (3) rodzinny, cechujący się częstszym spożywaniem posiłków z pozostałymi członkami rodziny. Powyższe wzory realizowało odpowiednio 11,8%, 24,6% i 63,6% dzieci.

Kwestionariusz CEBQ, oceniający zachowania żywieniowe podczas spożywania posiłków, zawiera 35 stwierdzeń opisujących osiem podskal (Wardle i wsp., 2001). Cztery z nich reprezentują cechy związane z podatnością na jedzenie i jedzeniem w reakcji na bodźce pokarmowe — reaktywność na jedzenie (FR), radość z jedzenia (EF), emocjonalne przejadanie się (EOE) i chęć picia (DD), a pozostałe cztery reprezentują cechy związane z niższym apetytem czy łatwiejszym odczuwaniem sytości – reaktywność na sytość (SR), wybredność w jedzeniu (FF), powolne jedzenie (SE) i emocjonalne ograniczanie jedzenia (EUE).

Najwyższy wynik kwestionariusza CEBQ w grupie badanej zaobserwowano w podskali EF (3,54 ± 0,75), a najniższy w podskali EOE (1,44 ± 0,51). Nie odnotowano istotnych różnic w wynikach poszczególnych podskali w zależności od wieku matki, regionu zamieszkania czy płci dziecka. Dzieci matek z wyższym poziomem wykształcenia uzyskały wyższe wyniki w podskali FF w porównaniu z niższym poziomem wykształcenia (2,65 ± 0,90 vs. 2,37 ± 0,83, $p \leq 0,05$). Zaobserwowano także różnice w zależności od wieku dziecka w podskalach: EF, SR, SE i FF. Najmłodsze dzieci uzyskały wyższe wyniki w podskali EF (3,73 ± 0,69) i niższe w podskali FF (2,26 ± 0,81) w porównaniu z dziećmi w wieku 19–24 miesiące (3,43 ± 0,80; 2,78 ± 0,90) oraz 25–36 miesięcy (3,42 ± 0,73, $p \leq 0,001$; 2,84 ± 0,87, $p \leq 0,001$, odpowiednio). W podskalach SR i SE różnice zaobserwowano tylko między dziećmi w wieku 12–18 i 19–24 miesiące. Młodsze dzieci uzyskały niższe wyniki w podskali SR (2,82 ± 0,61) i SE (2,69 ± 0,59) niż starsze dzieci (odpowiednio 3,03 ± 0,67, $p \leq 0,05$; 2,86 ± 0,64, $p \leq 0,05$).

Analizując wyniki kwestionariusza CEBQ, odnotowano różnice w wynikach podskali FR ($p \leq 0,01$), DD ($p \leq 0,01$) i SR ($p \leq 0,01$) w zależności od wzoru wczesnego żywienia, oraz wynikach w podskali SE ($p \leq 0,05$) w zależności od wieku wprowadzania pokarmów uzupełniających. Metoda wprowadzenia pokarmów uzupełniających była czynnikiem różnicującym wyniki w podskalach EF ($p \leq 0,001$) i FF ($p \leq 0,001$). Zaobserwowano również różnice między wynikami w podskali SR ($p \leq 0,05$) w zależności od rodzaju pokarmów uzupełniających, a także punktacją w podskalach EF ($p \leq 0,001$), DD ($p \leq 0,05$), SE ($p \leq 0,05$) i FF ($p \leq 0,001$) w zależności od sposobu spożywania posiłków.

W porównaniu ze wzorem wczesnego żywienia z dłuższym okresem wyłącznego karmienia piersią, wzór charakteryzujący się dłuższym okresem jakiegokolwiek karmienia piersią negatywnie oddziaływał na podskale EF (β= -0,178; 95% CI: -0,282 – -0,075) i DD (β= -0,183; 95% CI: -0,292 – -0,074) a pozytywnie na podskale SR (β= 0,158; 95% CI: 0,050 – 0,267) oraz SE (β= 0,146; 95% CI: 0,037 – 0,255). Z kolei wzór wczesnego żywienia charakteryzujący się karmieniem mieszanką mlekozastępczą, w porównaniu do wzoru wczesnego żywienia z dłuższym okresem wyłącznego karmienia piersią, związany był z wyższym wynikiem w podskali DD (β= 0,109; 95% CI: 0,006 – 0,212) i niższym w podskali SE (β= -0,105; 95% CI: -0,208 – -0,002).

Wzór żywieniowy, charakteryzujący się częstszym spożywaniem potraw przygotowywanych w domu, w porównaniu do opartego na produktach komercyjnych, związany był pozytywnie z wynikiem w podskali SR (β= 0,110; 95% CI: 0,009 – 0,210).

Odnotowano również zależność w odniesieniu do sposobu spożywania posiłków. W porównaniu do wzoru rodzinnego, wzór rozpraszający negatywnie oddziaływał na wynik podskali EF (β= -0,192; 95% CI: -0,321 – -0,064) i pozytywnie na punktację w podskalach DD (β= 0,150; 95% CI: 0,015 – 0,285) oraz SE (β= 0,160; 95% CI: 0,025 – 0,295).

Nie wykazano zależności pomiędzy metodą rozszerzania diety a zachowaniami żywieniowymi.

Podsumowując, wykazano związek między wczesnymi czynnikami żywieniowymi, takimi jak karmienie piersią, rodzaj wprowadzanych produktów uzupełniających oraz sposób spożywania posiłków a zachowaniami żywieniowymi dzieci w wieku 1-3 lata, takimi jak EF, DD, SR oraz SE. Wyniki dotyczące podskali takich jak EOE i EUE nie były istotne w żadnej z przeprowadzonych analiz. Spośród czynników socjodemograficznych tylko poziom wykształcenia matki i wiek dziecka różniły się w wynikach kwestionariusza CEBQ. Tym samym **częściowo potwierdzono hipotezę pierwszą**.

Uzyskane wyniki są istotne, ponieważ zachowania żywieniowe w okresie niemowlęctwa i wczesnego dzieciństwa mogą być czynnikami kształtującymi sposób żywienia również w późniejszych latach. Ponadto, zachowania żywieniowe mogą mieć związek z masą ciała dzieci czy różnorodnością diety (Sleddens i wsp., 2008; Jansen i wsp., 2012; Sandvik i wsp., 2018; Vilela i wsp., 2018; Ayine i wsp., 2021). Wartość odżywcza komercyjnych produktów dla niemowląt może być nieadekwatna do potrzeb żywieniowych małych dzieci. Jak wykazała analiza produktów uzupełniających, ok. 40% z nich charakteryzowało się zbyt niską wartością energetyczną, a w ponad połowie więcej niż 30% wartości energetycznej pochodziło z cukrów (WHO, 2021). Wobec powyższego, należy edukować rodziców małych dzieci na temat znaczenia karmienia piersią, rozszerzania diety czy tworzenia odpowiedniej atmosfery podczas spożywania posiłków.

Hipoteza 2: Wczesne i aktualne praktyki żywieniowe (karmienie piersią, rozszerzanie diety, sposób spożywania posiłków), zachowania żywieniowe oraz czas spędzany przed ekranem mają związek z wzorami żywieniowymi u małych dzieci.

Publikacja 2: Masztalerz-Kozubek D., Zielinska-Pukos M.A., Plichta M., Hamulka J.: The influence of early and current feeding practices, eating behaviors, and screen time on dietary patterns in Polish toddlers - a cross-sectional study. Appetite, 2024, 201, 107580. Doi: 10.1016/j.appet.2024.107580

Na podstawie danych z FFQ wyodrębniono trzy wzory aktualnego żywienia: (1) prozdrowotny, charakteryzujący się częstszym spożyciem świeżych owoców, warzyw, produktów zbożowych i mlecznych, ryb, nasion roślin strączkowych, olejów roślinnych, niesłodzonych/niesolonych orzechów i nasion/pestek, wody; (2) wybiórczy, charakteryzujący się niskim spożyciem analizowanych produktów spożywczych; (3) przetworzony, charakteryzujący się częstszym spożyciem słodzonych produktów zbożowych i smakowych produktów mlecznych, czerwonego mięsa, drobiu, przetworzonego mięsa, słodzonych/solonych orzechów i nasion/pestek, soków, słodyczy i słonych przekąsek. Blisko połowa dzieci przynależała do wzoru prozdrowotnego (45,0%), niecałe 30% do wybiórczego, a jedna czwarta (25,3%) – przetworzonego.

Analogicznie jak w publikacji 1, wyodrębniono trzy sposoby spożywania posiłków, również w odniesieniu do ostatnich trzech miesięcy żywienia dziecka – rozpraszający, osobny, rodzinny, które były realizowane odpowiednio przez 22,5%, 33,2% i 44,3% dzieci.

W jednoczynnikowej analizie regresji logistycznej, wśród dzieci karmionych wyłącznie piersią przez 1-4,9 miesiąca, szanse na przynależność do prozdrowotnego wzoru żywieniowego były zmniejszone o 71% w porównaniu z dziećmi, które były karmione wyłącznie piersią przez 5-7 miesięcy (OR 0,29, 95%CI: 0,16-0,52). Szanse te były również niższe, gdy w pierwszych 3 miesiącach rozszerzania diety dzieci przejawiały osobny lub rozpraszający sposób spożywania posiłków, w porównaniu do rodzinnego (OR 0,34, 95%CI: 0,23-0,51) oraz gdy częściej miały oferowane komercyjne produkty uzupełniające, w porównaniu z tymi, które częściej otrzymywały domowe (OR 0,32, 95%CI: 0,22-0,47).

W odniesieniu do ostatnich 3 miesięcy żywienia, dzieci, które obecnie nie były karmione piersią, miały o połowę niższe szanse na przynależność do prozdrowotnego wzoru żywieniowego w porównaniu z tymi, które były obecnie karmione piersią (OR 0.52, 95%CI: 0,35-0,76). Wśród dzieci spędzających czas przed ekranem, szanse były zmniejszone o 46% i 81% w porównaniu z dziećmi bez takiej ekspozycji, w zależności od czasu korzystania z urządzeń (odpowiednio: OR 0.54, 95%CI: 0,33-0,87; OR 0.19, 95%CI: 0,12-0,30). Jeśli chodzi o zachowania żywieniowe, dzieci z wyższymi wynikami w podskali FF miały mniejsze szanse na przynależność do prozdrowotnego wzoru żywieniowego (OR 0.54, 95%CI: 0,43-0,67), podczas gdy wyższy wynik w podskali EF zwiększał te szanse (OR 2,01, 95%CI: 1,54-2,63). W modelu wieloczynnikowym potwierdzono zależności między komercyjnym rodzajem produktów uzupełniających (aOR 0,42, 95%CI: 0,27-0,67), rozpraszającym sposobem spożywania posiłków w ostatnich 3 miesiącach (aOR 0,42, 95% CI: 0,22-0,83), wyższym wynikiem w podskali FF (aOR 0,70, 95% CI: 0,50-0,99) oraz czasem spędzonym przed ekranem, wynoszącym powyżej 30 minut dziennie (aOR 0,44, 95% CI: 0,24-0,82). Szanse na przynależność do wzoru prozdrowotnego były większe, gdy dzieci uzyskiwały wyższe wyniki w podskalach EF (aOR 1,52, 95% CI: 1,00-2,30) i SR (aOR 1,80, 95% CI: 1,19-2,73).

W modelu jednoczynnikowym, szanse na przynależność do wzoru wybiórczego były wyższe wśród dzieci, które podczas rozszerzania diety częściej spożywały komercyjne produkty uzupełniające w porównaniu z domowymi (OR 1,68, 95%CI: 1,12-2,50), miały rozpraszający lub osobny wzór spożywania posiłków w pierwszych (odpowiednio: OR 3,19, 95%CI: 1,76-5,77; OR 1,97, 95%CI: 1,24-3,14) i ostatnich 3 miesiącach (odpowiednio: OR 2,54, 95%CI: 1,52-4,26; OR 2,04, 95%CI: 1,27-3,27) w porównaniu z rodzinnym, oraz uzyskały wyższy wynik w podskali FF (OR 1,52, 95%CI: 1,21-1,90). Szanse te zmniejszały się wraz z wynikiem w podskali EF (OR 0,70, 95%CI: 0,53-0,91). W wieloczynnikowym modelu zależności te były istotne, gdy dzieci przejawiały rozpraszający sposób spożywania posiłków w pierwszych 3 miesiącach żywienia uzupełniającego i osobny w ostatnich 3 miesiącach (odpowiednio: aOR 2,35, 95% CI: 1,18-4,65; aOR 1,89, 95% CI: 1,12-3,19), oraz uzyskiwały wyższe wyniki w podskali FF (aOR 1,77, 95% CI: 1,26-2,48).

W odniesieniu do przetworzonego wzoru żywieniowego, analiza jednoczynnikowa wykazała, że dzieci, które były karmione wyłącznie piersią przez 1-4,9 miesiąca, miały wyższe szanse na przynależność do tego wzoru, w porównaniu z dziećmi, które były karmione wyłącznie piersią przez 5-7 miesięcy (OR 2,26, 95%CI: 1,28-4,01). Dzieci, które w pierwszych 3 miesiącach żywienia uzupełniającego częściej spożywały komercyjne produkty niż domowe, miały dwukrotnie wyższe szanse na przynależność do przetworzonego wzoru żywieniowego (OR 2,39, 95%CI: 1,56-3,67). Wśród dzieci, które przejawiały rozpraszający sposób spożywania posiłków, zarówno w pierwszych (OR 1,96, 95%CI: 1,06-3,62), jak i ostatnich 3 miesiącach (OR 2,21, 95%CI: 1,34-3,64), te szanse były około dwukrotnie wyższe w porównaniu z dziećmi, które prezentowały rodzinny sposób spożywania posiłków. Brak aktualnego karmienia piersią zwiększał szanse na przynależność do przetworzonego wzoru żywieniowego w porównaniu z grupą dzieci, które były nadal karmione piersią (OR 2,95, 95%CI: 1,80-4,85). Również dzieci, które uzyskały wyższy wynik w podskali FF, miały te szanse zwiększone o około 30% (OR 1,36, 95%CI: 1,07-1,71). Czas spędzony przed ekranem istotnie zwiększał szanse na przynależność do tego wzorca – od 3 do 11 razy (<30 minut: OR 3,21, 95%CI: 1,56-6,58; 30-60 minut: OR 7,38, 95%CI: 3,72-14,65; >60 minut: OR 11,06, 95%CI: 4,94-24,75), w porównaniu z grupą dzieci bez ekspozycji na ekrany. Szanse na przynależność do wzoru przetworzonego były niższe, gdy dzieci w ostatnich 3 miesiącach spożywały posiłki w innych porach niż rodzina (OR 0,53, 95%CI: 0,31-0,92), w porównaniu z rodzinnym spożywaniem posiłków, oraz uzyskały wyższe wyniki w podskali EF (OR 0,64, 95%CI: 0,48-0,85). W modelu wieloczynnikowym potwierdzono zależności między następującymi zmiennymi: komercyjnym rodzajem produktów uzupełniających (aOR 2,07, 95% CI: 1,26-3,41), brakiem obecnego karmienia piersią (aOR 1,96, 95% CI: 1,10-3,50), czasem spędzonym przed ekranem (<30 minut – aOR 2,27, 95% CI: 1,05-4,93; 30-60 minut – aOR 4,14, 95% CI: 1,89-9,06; >60 minut – aOR 5,46, 95% CI: 2,03-14,69) oraz wynikiem w podskali EF (aOR 0,60, 95% CI: 0,39-0,94).

Podsumowując, wykazano, że czynniki takie jak wyższy wynik w podskali EF i SR zwiększały szanse na przynależność do prozdrowotnego wzoru żywieniowego, a komercyjny wzór żywienia uzupełniającego (w porównaniu z domowym), rozpraszający sposób spożywania posiłków, wyższy wynik w podskali FF oraz czas spędzony przed ekranem zmniejszały te szanse. Rozpraszający sposób spożywania posiłków w pierwszych 3 miesiącach rozszerzania diety oraz osobny w ostatnich 3 miesiącach żywienia, jak również wyższy wynik w podskali FF zwiększyły szanse na przejawianie wzoru wybiórczego, podczas gdy komercyjny wzór żywienia uzupełniającego, brak obecnego karmienia piersią oraz czas spędzony przed ekranem zwiększyły szanse na przynależność do przetworzonego wzoru żywieniowego. Niniejszym, **hipoteza druga została częściowo potwierdzona**.

Wyniki badania opisane w publikacji 2 podkreślają istotę pierwszych lat życia w kontekście kształtowania wzorów żywieniowych. Oferowanie domowych posiłków podczas rozszerzania diety, dłuższe karmienie piersią, dbanie o dobrą atmosferę podczas spożywania posiłków, kształtowanie zachowań żywieniowych związanych z zainteresowaniem jedzeniem, responsywnym jedzeniem i mniejszą wybiórczością żywieniową, jak również ograniczanie czasu spędzanego przed ekranem mogą być pomocnymi strategiami w budowaniu korzystnych nawyków żywieniowych. Okres wczesnodziecięcy wydaje się w tym kontekście niezwykle istotny, gdyż nowe produkty są częściej akceptowane przez dzieci w tym wieku niż w latach późniejszych, gdy wzory żywieniowe wydają się już wykształcone (Mennella, 2014).

Hipoteza 3: Wczesne i aktualne czynniki żywieniowe (karmienie piersią, rozszerzanie diety, spożycie wybranych grup produktów spożywczych, suplementacja witaminy D) jak również wskaźniki antropometryczne mają związek z jakością kośćca u dzieci w wieku przedszkolnym.

Publikacja 3: Masztalerz-Kozubek D., Zielinska-Pukos M.A., Hamulka J.: Sex-specific effects of a Mediterranean diet on lower limb bone strength in Polish children. Bone, 2024, 189, 117252. Doi: 10.1016/j.bone.2024.117252

W badaniu tym, dotyczącym dzieci w wieku 3-7 lat, zidentyfikowano dwa wzory wczesnego żywienia. Pierwszy wzór charakteryzował się krótszym czasem trwania zarówno wyłącznego, jak i jakiegokolwiek karmienia piersią oraz wcześniejszym wprowadzeniem pokarmów stałych. Drugi wzór wykazywał dłuższy czas trwania karmienia piersią, zarówno wyłącznego, jak i jakiegokolwiek oraz późniejsze wprowadzenie pokarmów stałych. Wzory były realizowane przez odpowiednio 61,0% i 39,0% dzieci.

Mediana punktacji uzyskanej w indeksie MVP-aMED wynosiła 3,0 (2,0 – 5,0). Większość dzieci otrzymywała suplement witaminy D od urodzenia do momentu badania (75,6%) i miała prawidłową masę ciała (82,9%). Średnia wartość QUS z-score i mediana BMI z-score wynosiły odpowiednio -0,13 ± 1,20 i 0,09 (-0,40 – 0,75). Odnotowano istotne statystycznie różnice między dziewczynkami a chłopcami w odniesieniu do wyniku QUS z-score i wyniku BMI z-score, przy czym chłopcy wykazywali wyższe wartości w porównaniu z dziewczynkami – odpowiednio 0,11 ± 1,17 vs -0,32 ± 1,2, p=0,01 i 0,31 (-0.25 – 0,88) vs 0,00 (-0,47 – 0,67), p=0,04.

W jednoczynnikowej analizie regresji liniowej nie wykazano żadnych różnic między analizowanymi zmiennymi. Biorąc pod uwagę płeć, u dziewcząt wykazano różnice między wynikiem indeksu MVP-aMED i wskaźnikiem BMI z-score a QUS z-score. Dziewczynki, których dieta charakteryzowała się większym przystosowaniem do diety śródziemnomorskiej, miały wyższy wynik QUS z-score, świadczący o lepszej jakości kośćca (β= 0,193, 95% CI: 0,005 – 0,237). Z kolei dziewczynki, które miały nadwagę lub otyłość, miały niższy wynik QUS z-score (β= -0,318, 95% CI: -1,455 – -0,039), w porównaniu do tych z prawidłową masą ciała. W modelu wieloczynnikowym potwierdzona została zależność jedynie z dietą śródziemnomorską (β= 0,209, 95% CI: 0,007 – 0,255).

Podsumowując, wykazano, że wyższy stopień realizacji diety śródziemnomorskiej u dziewcząt w wieku 3-7 lat był powiązany z lepszą jakością kośćca. Związek z masą ciała został odnotowany jedynie w modelu jednoczynnikowym. Powyższe wyniki **częściowo potwierdziły hipotezę trzecią**.

Wyniki publikacji 3 podkreślają istotę kształtowania korzystnych nawyków żywieniowych i utrzymywania prawidłowej masy ciała u dzieci, w celu zapewnienia optymalnego rozwoju kośćca.

6. Stwierdzenia i wnioski

Badania przeprowadzone w ramach niniejszej rozprawy doktorskiej pozwoliły na realizację celu badawczego i częściową weryfikację postawionych hipotez.

Na podstawie otrzymanych wyników sformułowano następujące **stwierdzenia**:

1. Długość karmienia piersią, rodzaj produktów uzupełniających oraz sposób spożywania posiłków w pierwszych latach życia miały związek z zachowaniami żywieniowymi wśród dzieci w wieku 1-3 lata.
2. Dłuższe karmienie piersią oraz częstsze podawanie domowych posiłków uzupełniających wiązały się z wyższym wynikiem w podskali reaktywność na sytość (SR), który może świadczyć o bardziej adaptacyjnym stylu jedzenia, związanym m.in. ze spożywaniem posiłków w odpowiedzi na wewnętrzne sygnały głodu biologicznego i sytości, a nie na bodźce emocjonalne.
3. Częstsze podawanie komercyjnych produktów uzupełniających, rozpraszający sposób spożywania posiłków, większa wybredność w jedzeniu (FF) jak i spędzanie czasu przed ekranem zmniejszały szanse na przynależność do wzoru prozdrowotnego wśród dzieci w wieku 1-3 lata. Z kolei zachowania żywieniowe takie jak większa radość z jedzenia (EF) oraz reaktywność na sytość (SR) zwiększały te szanse. Ryzyko przejawiania wzoru żywieniowego określanego jako wybiórczy było większe, gdy dzieci spożywały posiłki w sposób rozpraszający w pierwszych 3 miesiącach rozszerzania diety i osobno w ostatnich 3 miesiącach, jak również miały wyższy wynik w podskali wybredność w jedzeniu (FF). Częstsze spożywanie komercyjnych produktów uzupełniających, brak obecnego karmienia piersią, jak również czas przed ekranem zwiększały szanse na przynależność do przetworzonego wzoru żywieniowego, a czynnikiem zmniejszającym to ryzyko był większa radość z jedzenia (EF).
4. Wyższy wynik indeksu MVP-aMED, świadczący o większym stopniu realizacji diety śródziemnomorskiej, był powiązany z lepszą jakością kośćca, co wynikało z wyższych wartości QUS z-score u dziewcząt w wieku 3-7 lat. Nadwaga lub otyłość określone na postawie wskaźnika BMI z-score były z kolei związane z niższą jakością kośćca w tej samej grupie badanej, jednak wynik ten nie został potwierdzony w analizie wieloczynnikowej.

W oparciu o uzyskane wyniki i powyższe stwierdzenia wyciągnięto następujące **wnioski**:

1. **Czynniki żywieniowe w okresie wczesnodziecięcym**, takie jak karmienie piersią, rodzaj produktów uzupełniających, jak również atmosfera podczas spożywania posiłków mogą być **istotne w kontekście kształtowania zachowań żywieniowych**.
2. **Wczesne praktyki żywieniowe** (długość karmienia piersią, rodzaj produktów uzupełniających, obecność dystraktorów podczas posiłków), jak również **zachowania związane z zainteresowaniem jedzeniem, bardziej responsywnym stylem jedzenia, wybiórczością pokarmową** oraz **elementy stylu życia** (czas spędzany przed ekranem) mogą wpływać na **przynależność do wybranych wzorów żywieniowych**. Stosowanie odpowiednich praktyk żywieniowych i kształtowanie zachowań żywieniowych, jak również ograniczanie czasu spędzanego przed ekranem mogą zatem stanowić strategię kształtowania prozdrowotnych zachowań żywieniowych, wspierających prawidłowy rozwój i zdrowie dzieci.
3. **Przestrzeganie diety śródziemnomorskiej** może być powiązane z **lepszą jakością kośćca** u dziewczynek w wieku przedszkolnym. Konieczne są dalsze badania, w których oceniony zostanie długoterminowy wpływ wczesnego żywienia na zdrowie kości.
4. **Niektóre praktyki żywieniowe** (dłuższe karmienie piersią, oferowanie domowych, dostosowanych do dziecka produktów uzupełniających, unikanie dystraktorów podczas spożywania posiłków, częstsze wspólne posiłki, przestrzeganie diety śródziemnomorskiej) oraz **ograniczanie czasu spędzanego przez dzieci przed ekranem** mogą być szczególnie istotne w kontekście **kształtowania korzystnych zachowań żywieniowych, prozdrowotnych wzorów żywieniowych czy lepszej jakości kośćca**. W związku z powyższym należy zwrócić uwagę na te aspekty w edukacji żywieniowej rodziców małych dzieci.

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8. Kopie opublikowanych prac

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Article

Early Feeding Factors and Eating Behaviors among Children Aged 1–3: A Cross-Sectional Study

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Abstract: Early nutrition plays a crucial role not only in providing essential nutrients for proper child development, but may also be an important step in creating desirable eating behaviors, which can be transmitted into adulthood. The aim of this study was to assess possible links between early feeding factors, such as breastfeeding, complementary feeding (timing and method) as well as types of complementary foods and mealtime environment during the first three months of complementary feeding and eating behaviors in children aged 1–3 years old. This cross-sectional, online survey involved 467 mothers of toddlers aged 1–3 years old from the whole of Poland. The questionnaire consisted of questions about early feeding and the Children's Eating Behavior Questionnaire (CEBQ). The adjusted linear regression model revealed that longer duration of any breastfeeding was negatively related to enjoyment of food (EF), desire to drink (DD) and positively related to satiety responsiveness (SR) and slowness in eating (SE) subscales. Moreover, offering homemade complementary foods more often than commercial may be related to higher SR. Eating meals during distraction seems to be negatively associated with EF, and positively with DD and SE subscales. Our study highlights possible links between early feeding factors and toddlers' eating behaviors, so further investigation, also including dietary factors, is needed.

Keywords: breastfeeding; complementary feeding; complementary feeding method; complementary foods; mealtime environment; eating behaviors; infant feeding practices; CEBQ

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1. Introduction

Nutrition during early life is an important factor in shaping food preferences and eating behaviors that can be transferred into childhood and beyond [1,2]. Development of healthy eating habits influences later health and may prevent obesity and other non-communicable diseases which are considered as social and public health problems [2,3].

Among early nutrition factors, breastfeeding and complementary feeding play a major role. Exclusive breastfeeding for the first 6 months of life is a desirable goal in infants' nutrition and should be continued as complementary foods are introduced, as long as mutually desired by mother and infant [4,5]. Breastfeeding, besides having many health benefits both for mother and child [6], may also contribute to establishing food preferences and eating behaviors [1,7–9].

Complementary feeding is the next stage in infant's feeding. It is possible to start introducing solids between 17 and 26 weeks [10,11]; however, exclusive breastfeeding for 6 months is a gold standard in infants' nutrition and, during this time, breast milk provides all the essential nutrients in the majority of children [10]. However, besides timing, psychological and neurological maturation is also crucial [10]. Complementary feeding is a gradual process of introduction foods and beverages other than breastmilk/formula and it typically continues to 24 months [12,13]. Complementary feeding, besides its role in providing nutrients, is also an important period in the acquirement of an optimal eating behavior and healthy eating habits [12]. Responsive feeding, in which the child leads the feeding interaction, in contrast to it being the parent's responsibility over what, when and where a child is fed, seems to play an important role in the context of shaping food preferences and establishing desirable eating behaviors [13,14].

There is no concise recommendation about method of complementary feeding or type of complementary foods [10]. Over the last year, interest in baby-led weaning method (BLW) has grown substantially, suggesting much promise in relation to possible benefits of BLW to infant eating behaviors; however, results are inconclusive [14]. To the best of our knowledge, the number of studies focusing on types of complementary foods in relation to eating behavior is scarce. On the one hand, WHO reports suggest that the nutrition quality of commercial complementary foods may be inadequate [15,16]. On the other hand, there is a possible risk of offering unsuitable family foods, with the addition of salt/sugar.

Another factor, besides timing and method of introducing complementary foods, that may be important in creating healthy eating behaviors is mealtime environment. Previous studies have suggested that frequent family mealtimes may be associated with more desirable eating behaviors, better diet quality as well as decreased risk of overweight/obesity and eating disorders [7,17,18]. In addition, meal consumption during distraction, such as watching television, may be a risk factor for developing unhealthy food habits [19].

Recent studies have analyzed eating behaviors in the context of early feeding factors; however, results are inconclusive [8,20–28]. Moreover, previous studies sometimes focused on selected early feeding factors such as breastfeeding [24,28], complementary feeding [29,30] or mealtime habits [18,31,32] only.

The aim of the present study was to assess possible links between breastfeeding, complementary feeding (timing and method) as well as types of complementary foods and mealtime environment during the first three months of complementary feeding and eating behaviors in children aged 1–3 years old.

2. Materials and Methods

2.1. Study Design and Participants

The study followed the ethical standards recognized by the Declaration of Helsinki and was approved by the Ethics Committee of the Faculty of Human Nutrition and Consumer Science, Warsaw University of Life Sciences, Poland, on 19/07/2019 (Resolution No. 45/2019).

The study was designed as a cross-sectional study among mothers of children aged 1–3 years old from Poland. Data related to the study were collected in 2020–2022, with the use of the CAWI (Computer-Assisted Web Interview) method. Mothers were recruited through social media. The questionnaire was published in parenthood-specific discussion boards using the Google Forms web survey platform. The link to the online survey was shared through social media, such as Facebook, Instagram, and WhatsApp, and by personal contacts of the research group members. Participants received information about the anonymity of the study, the voluntary nature and the possibility to stop their participation at any study stage.

The inclusion criteria were formulated as follows:

- Internet access;
- Living in Poland;
- Willingness to participation in the study.

The exclusion criteria were:

- Child's age less than 12 or more than 36 months;
- Living abroad;
- Lack or incomplete data about breastfeeding, complementary feeding, and maternal anthropometry;
- Gestational age less than 23 or more than 44 weeks.

The questionnaire was completed by 603 participants and 467 (77% of initial sample) of them were included in the final analysis (Figure 1). Participants were excluded due to lack of or incomplete data, living abroad, child's age (less than 12 or more than 36 months) and extreme gestational age.

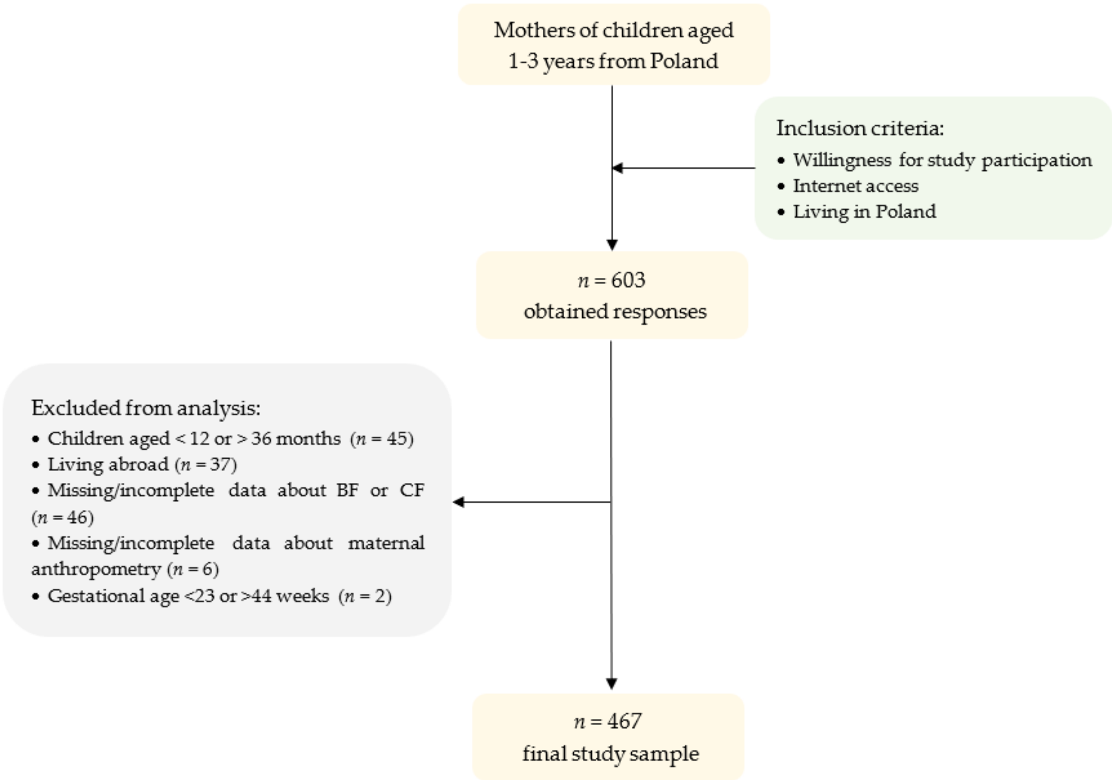

Figure 1. Flowchart presenting exclusion criteria and study population. BF—breastfeeding; CF—complementary feeding.

2.2. Questionnaire

The questionnaire comprised questions about early and current feeding practices, birth-related and demographic data, as well as questions regarding child and maternal anthropometry. One of the parts of the survey was the Children's Eating Behavior Questionnaire (CEBQ).

2.2.1. Early Feeding Practices

Mothers were asked about milk feeding practices—whether they ever breastfed and for how long. Information about duration of any and exclusive breastfeeding was gathered. Due to the definition of exclusive breastfeeding [33], if an infant received water or any other food/drink product during the declared period of exclusive breastfeeding, the duration was adequately corrected.

Additionally, mothers were asked about the first 3 months of complementary feeding period, such as age at when they introduced particular food/drink products. On this basis, we calculated age when infants started complementary feeding. Time of introducing complementary feeding was defined as the month when children received for the first time any other than breastmilk/formula product (including water; not applying to water that was an ingredient of formula milk). Among infants who were born prematurely, we reported data expressed in corrected age. Age at complementary feeding introduction was categorized as (1) complementary feeding started before 4 months, (2) before 4 and 6 months, (3) after 6 months. Information about method of complementary foods introduction was also gathered. Baby-led weaning (BLW) was defined as solely or mostly baby feeding themselves, mixed method as about half spoon-feeding by an adult and half baby feeding themselves, and tablespoon feeding (TSF) as mostly or solely spoon-fed by an adult. Data about types (commercial baby foods and drinks, homemade adapted for infants, family foods) of complementary foods and mealtime environment (with family, during watching TV, distraction, playtime) were also examined.

2.2.2. Feeding Practices and Toddlers' Dietary Habits in the Last 3 months

We also asked about current feeding practices, such as mentioned above mealtime environment, frequency of consumption of selected food items and use of added salt and sugar in the toddlers' diets.

Children's Eating Behavior Questionnaire

Current eating behaviors were assessed using the Children's Eating Behavior Questionnaire (CEBQ) completed by mothers. It is a 35-item tool, where respondents rate each item on a 5-point Likert scale from 1 (never) to 5 (always). Results for each subscale were calculated as the mean from all items in the given subscale.

CEBQ is a psychometric tool for assessing eating behaviors in children and was originally developed and validated by Wardle et al. [34]. Since then, CEBQ in original or modified versions has been used in multiple studies, involving wide age ranges of study subjects (from 12 months [35] up to 16 years old [20,36–43]). Originally, the CEBQ included eight subscales, four of them representing "food approach" traits—food responsiveness (FR), enjoyment of food (EF), emotional overeating (EOE), and desire to drink (DD), with the remaining four representing "food avoidance" eating traits—satiety responsiveness (SR), food fussiness (FF), slowness in eating (SE) and emotional undereating (EUE) [44,45]. Appetitive traits can vary with age; nonetheless, some studies showed good continuity/stability of selected eating behaviors over time [42,46,47]. In this research we used the polish version of CEBQ adapted by Czepczor-Bernat and Brytek-Matera [36].

2.2.3. Children and Maternal Anthropometry

Information about current toddlers' body weight and height were gathered. On this basis, BMI z-scores were calculated using the WHO Anthro Survey Analyser [48] and interpreted according to WHO criteria [49]. Mothers were also asked about their weight and height; based on these data, maternal BMI was calculated and interpreted based on the WHO [50].

2.2.4. Birth-Related Data

In this part of the survey, mothers were asked about type of pregnancy (singleton or multiple), gestational age (in weeks) and birth parameters. Children who were born before 37 weeks of pregnancy were categorized as 'premature' and then corrected age was calculated. On the basis of birthweight and gestational age, we calculated birthweight to gestational age centiles, using the INTERGROWTH-21st Neonatal Size Calculator [51] and interpreted results as follows: small for gestational age (SGA) as lower than 10th percentile, appropriate to gestational age (AGA) as 10th–90th percentile and large for gestational age (LGA) as higher than 90th percentile.

2.2.5. Toddlers' Health and Development

Data about toddlers' health conditions, such as occurrence of food allergies, hyper- and hypotonia, atopic dermatitis, sensory integration disorders, sleep duration, screen time, attendance to daycare and maternal opinion about toddlers' body weight were obtained.

2.2.6. Demographic Data

The following data were gathered: parental age and education level (further categorized as follows: (1) less than 29 years, (2) 30–34 years, (3) 35 years or more and (1) high school or lower, (2) university, respectively), place of residence—size and region of the country, further categorized according to the gross domestic product (GDP) per capita in purchasing power standards in relation to EU-27 average [52] ((1) 51–100%—Lower Silesian, Kuyavian-Pomeranian, Lublin, Lubusz, Łódź, Lesser Poland, Opole, Subcarpathian, Podlaskie, Pomeranian, Silesian, Holy Cross, Warmian-Masurian, Greater Poland, West Pomeranian voivodships; (2) 101–130%—Masovian voivodship), number of persons and children in the household. For the children, information about current age (further categorized into three age groups: (1) 12–18 months, (2) 19–24 months, (3) 25–36 months) and sex was obtained.

2.3. Statistical Analysis

Qualitative data were reported as a percentage (%) and numbers (n) and quantitative data as a mean $\pm$ standard deviation (SD). After checking the normality of distribution by Kolmogorov–Smirnov test, we used U-Mann–Whitney or Kruskal–Wallis tests to check differences between variables.

Early feeding practices, types of complementary food and mealtime environment in the first three months of complementary feeding patterns were determined using the *k-means* algorithm. Early feeding pattern included data about exclusive breastfeeding duration, age at complementary feeding introduction and current breastfeeding. Three clusters were selected: (1) longer ABF, characterized by current breastfeeding but lower exclusive breastfeeding duration (4.1 $\pm$ 2.4 months) and complementary feeding at 5.6 $\pm$ 0.9 months; (2) formula, with very low exclusive breastfeeding duration (0.3 $\pm$ 0.7 months), lack of current breastfeeding and introduction of complementary foods at 4.3 $\pm$ 1.9 months; (3) longer EBF, characterized by lack of current breastfeeding but longer duration of exclusive breastfeeding (5.4 $\pm$ 0.9 months) and complementary feeding introduction at 5.6 $\pm$ 0.9 months (Table S1). In the types of complementary food pattern, we selected two clusters: (1) homemade, characterized by more frequent consumption of homemade meals cooked especially for baby and family meals adjusted for babies, and (2) commercial, characterized by more frequent consumption of commercial foods for babies (cereals, fruit/dinner/soup jars) (Table S2). In the mealtime environment (during first three months of complementary feeding) pattern, three clusters were selected: (1) distracted, in which infants ate more often while doing other activities (such as watching TV, playtime, or were distracted by parent); (2) separated, characterized by more frequent meal consumption at different times than other family members; (3) family, characterized by more frequent meal consumption with the rest of family (Table S3).

3. Results

In the study population, nearly half of the mothers were 30–34 years old (47.5%), most of them had university education (85.2%) and lived in macroeconomic region with 51–100% of GDP EU-27 average (77.1%; Table 1). Most of the children were born in term (91.0%), and had appropriate to gestational age birthweight (77.1%; Table S4). One-third (31.3%) of toddlers were exclusively breastfed for at least 6 months and nearly 40% of mothers were currently breastfeeding. More than 80% of the children were introduced to complementary foods between 4 and 6 months.

Table 1. Sociodemographic characteristics of the study sample according to CEBQ results.

Variable	*n*	%	CEBQ Subscales							
			FR	EOE	EF	DD	SR	SE	EUE	FF
Total	467	100.0	2.05 ± 0.73	1.44 ± 0.51	3.54 ± 0.75	2.74 ± 0.87	2.92 ± 0.64	2.76 ± 0.61	2.59 ± 0.98	2.61 ± 0.90
Maternal age (years):										
<29	145	31.0	2.13 ± 0.84	1.47 ± 0.52	3.62 ± 0.77	2.80 ± 0.93	2.84 ± 0.68	2.77 ± 0.65	2.64 ± 0.96	2.49 ± 0.89
30–34	222	47.5	2.05 ± 0.69	1.46 ± 0.51	3.53 ± 0.74	2.77 ± 0.82	2.95 ± 0.62	2.75 ± 0.58	2.64 ± 0.97	2.66 ± 0.89
≥35	100	21.4	1.90 ± 0.63	1.37 ± 0.46	3.44 ± 0.72	2.60 ± 0.86	2.94 ± 0.64	2.81 ± 0.61	2.41 ± 1.01	2.67 ± 0.91
	***p*-value**		0.147	0.213	0.112	0.169	0.478	0.747	0.077	0.221
Maternal education:										
high school and lower	69	14.8	2.10 ± 0.82	1.45 ± 0.49	3.61 ± 0.69	2.83 ± 0.90	2.86 ± 0.66	2.85 ± 0.70	2.59 ± 0.94	2.37 ± 0.83
university	398	85.2	2.04 ± 0.72	1.44 ± 0.51	3.53 ± 0.76	2.73 ± 0.86	2.93 ± 0.64	2.75 ± 0.59	2.59 ± 0.99	2.65 ± 0.90
	***p*-value**		0.724	0.876	0.496	0.475	0.615	0.286	0.897	0.026
Macroeconomic region residence (% GDP EU-27 average):										
51–100	360	77.1	2.07 ± 0.73	1.43 ± 0.50	3.53 ± 0.74	2.76 ± 0.88	2.90 ± 0.65	2.77 ± 0.62	2.55 ± 0.97	2.61 ± 0.88
101–130	107	22.9	1.97 ± 0.72	1.47 ± 0.53	3.56 ± 0.76	2.67 ± 0.82	2.98 ± 0.59	2.75 ± 0.56	2.74 ± 1.02	2.60 ± 0.96
	***p*-value**		0.213	0.465	0.657	0.331	0.152	0.781	0.097	0.786
Child's gender:										
female	233	49.9	2.07 ± 0.71	1.47 ± 0.54	3.51 ± 0.74	2.71 ± 0.87	2.97 ± 0.61	2.80 ± 0.63	2.64 ± 0.92	2.58 ± 0.88
male	234	50.1	2.03 ± 0.76	1.42 ± 0.47	3.56 ± 0.75	2.77 ± 0.87	2.86 ± 0.67	2.73 ± 0.59	2.54 ± 1.04	2.64 ± 0.91
	***p*-value**		0.345	0.693	0.622	0.353	0.114	0.294	0.177	0.482
Child's age (months):										
12–18	176	37.7	2.08 ± 0.75	1.44 ± 0.49	3.73 ± 0.69^{a}	2.68 ± 0.88	2.82 ± 0.61^{a}	2.69 ± 0.59^{a}	2.55 ± 1.01	2.26 ± 0.81^{a}
19–24	120	25.7	2.03 ± 0.81	1.41 ± 0.50	3.43 ± 0.80^{b}	2.75 ± 0.91	3.03 ± 0.67^{b}	2.86 ± 0.64^{b}	2.58 ± 1.02	2.78 ± 0.90^{b}
25–36	171	36.6	2.03 ± 0.65	1.47 ± 0.52	3.42 ± 0.73^{b}	2.81 ± 0.82	2.94 ± 0.64^{ab}	2.77 ± 0.60^{ab}	2.64 ± 0.93	2.84 ± 0.87^{b}
	***p*-value**		0.636	0.574	≤0.001	0.288	0.024	0.045	0.629	≤0.001

^{a,b}—values with different superscript letters are significantly different ($p \leq 0.05$); FR—food responsiveness, EOE—emotional overeating, EF—enjoyment of food, DD—desire to drink, SR—satiety responsiveness, SE—slowness in eating, EUE—emotional undereating, FF—food fussiness; GDP—gross domestic product.

3.1. Sociodemographic Factors and Eating Behaviors

Results regarding the Children's Eating Behavior Questionnaire are listed in Table 1. The highest score was observed on the EF subscale (3.54 $\pm$ 0.75), whereas the lowest was observed on the EOE subscale (1.44 $\pm$ 0.51). We did not notice any differences between maternal age, macroeconomic region residence or child's gender and CEBQ measures (Table 1). However, children of mothers with a higher education level scored higher on the FF subscale compared to children of mothers with a lower education level (2.65 $\pm$ 0.90 vs. 2.37 $\pm$ 0.83, $p \leq 0.05$). We also observed differences between child's age and EF, SR, SE and FF subscales. The youngest children scored higher on the EF subscale (3.73 $\pm$ 0.69) and lower on the FF subscale (2.26 $\pm$ 0.81) when compared to those aged 19–24 (3.43 $\pm$ 0.80; 2.78 $\pm$ 0.90) and 25–36 months (3.42 $\pm$ 0.73, $p \leq 0.001$; 2.84 $\pm$ 0.87, $p \leq 0.001$, respectively). On the SR and SE subscales, differences were observed only between children aged 12–18 and 19–24 months. Younger children scored lower on SR (2.82 $\pm$ 0.61) and SE (2.69 $\pm$ 0.59) subscales than older children (3.03 $\pm$ 0.67, $p \leq 0.05$; 2.86 $\pm$ 0.64, $p \leq 0.05$, respectively) (Table 1).

3.2. Birth-Related Factors, Maternal BMI and Eating Behaviors

Children with lower birthweight scored lower on the FR subscale (1.64 $\pm$ 0.45) than those with a higher birthweight (2.07 $\pm$ 0.75, $p \leq 0.05$). We did not notice any other differences between pregnancy duration, birthweight to gestational age categories or maternal BMI and eating behaviors (Table S4).

3.3. Early Feeding Factors and Eating Behaviors

Table 2 lists the data on early feeding pattern, age and method of complementary feeding introduction, types of complementary food and mealtime environment patterns. We noticed differences between early feeding pattern and results in FR ($p \leq 0.01$), DD ($p \leq 0.01$) and SR ($p \leq 0.01$) subscales and between age at complementary feeding introduction and scores in SE subscale ($p \leq 0.05$). Method of complementary feeding introduction was a factor that varied on the EF ($p \leq 0.001$) and FF ($p \leq 0.001$) subscales. We also observed differences between types of complementary food pattern and results on the SR subscale ($p \leq 0.05$), as well as mealtime environment pattern and scores on the EF ($p \leq 0.001$), DD ($p \leq 0.05$), SE ($p \leq 0.05$) and FF ($p \leq 0.001$) subscales.

3.4. Early Feeding Factors Associating with the CEBQ Results

Results of linear regression analysis are presented in Table 3 (multivariate model) and Table 4 (model adjusted for children age, gender and maternal education). The univariate model is included in Supplementary Materials (Table S5).

3.4.1. Early Feeding Pattern

In the univariate regression analysis, we noticed a negative association between pattern with a longer duration of any breastfeeding and scores in FR ($\beta = -0.160$, 95% CI: -0.260–-0.060, $p \leq 0.01$) and DD ($\beta = -0.194$, 95% CI: -0.294– -0.094, $p \leq 0.001$) subscales. Moreover, formula feeding pattern was positively associated with higher scores on the DD subscale ($\beta = 0.119$, 95% CI: 0.019–0.219, $p \leq 0.05$; Table S5).

In the multivariate model, association with FR subscale was no longer significant, whereas associations with DD and SR subscales remained significant both in multivariate (DD: longer ABF $\beta = -0.187$, 95% CI: -0.289– -0.085, $p \leq 0.001$, formula $\beta = 0.114$, 95% CI: 0.013–0.215, $p \leq 0.01$; SR: longer ABF $\beta = 0.117$, 95% CI: 0.014–0.220, $p \leq 0.05$; Table 3) and adjusted models (DD: longer ABF $\beta = -0.183$, 95% CI: -0.292– -0.074, $p \leq 0.01$, formula $\beta = 0.109$, 95% CI: 0.006–0.212, $p \leq 0.05$; SR: longer ABF $\beta = 0.158$, 95% CI: 0.050–0.267, $p \leq 0.01$; Table 4).

Table 2. Early feeding practices according to CEBQ results.

Variable	*n*	%	CEBQ Subscales							
			FR	EOE	EF	DD	SR	SE	EUE	FF
Early feeding pattern:										
longer ABF	174	37.1	1.91 ± 0.65 ^{a}	1.43 ± 0.46	3.50 ± 0.69	2.55 ± 0.80 ^{a}	3.00 ± 0.56 ^{a}	2.83 ± 0.60	2.63 ± 1.01	2.54 ± 0.85
formula	160	34.3	2.09 ± 0.76 ^{ab}	1.41 ± 0.50	3.50 ± 0.85	2.89 ± 0.93 ^{b}	2.89 ± 0.73 ^{ab}	2.70 ± 0.63	2.56 ± 0.99	2.63 ± 0.96
longer EBF	133	28.5	2.17 ± 0.78 ^{b}	1.50 ± 0.56	3.63 ± 0.69	2.83 ± 0.83 ^{b}	2.83 ± 0.63 ^{b}	2.75 ± 0.60	2.58 ± 0.94	2.67 ± 0.87
	***p*-value**		0.009	0.434	0.298	0.002	0.009	0.173	0.805	0.489
Age at CFI (months):										
<4	54	11.6	2.03 ± 0.77	1.37 ± 0.49	3.29 ± 0.84	3.03 ± 1.14	3.05 ± 0.80	2.77 ± 0.70 ^{ab}	2.69 ± 1.02	2.89 ± 0.98
4–6	380	81.4	2.05 ± 0.74	1.45 ± 0.52	3.58 ± 0.74	2.71 ± 0.83	2.90 ± 0.62	2.74 ± 0.59 ^{a}	2.58 ± 0.98	2.56 ± 0.88
≥7	33	7.1	2.00 ± 0.63	1.45 ± 0.39	3.52 ± 0.62	2.66 ± 0.69	2.93 ± 0.57	3.03 ± 0.61 ^{b}	2.54 ± 0.91	2.69 ± 0.87
	***p*-value**		0.933	0.260	0.062	0.283	0.611	0.030	0.821	0.051
CF method:										
BLW	134	28.7	2.03 ± 0.71	1.41 ± 0.45	3.66 ± 0.76 ^{a}	2.62 ± 0.78	2.98 ± 0.56	2.76 ± 0.60	2.51 ± 0.96	2.50 ± 0.90 ^{a}
mixed	141	30.2	2.06 ± 0.79	1.49 ± 0.54	3.63 ± 0.72 ^{a}	2.74 ± 0.86	2.86 ± 0.61	2.70 ± 0.58	2.59 ± 0.94	2.45 ± 0.81 ^{a}
TSF	192	41.1	2.04 ± 0.71	1.43 ± 0.52	3.38 ± 0.73 ^{b}	2.84 ± 0.92	2.92 ± 0.71	2.81 ± 0.64	2.64 ± 1.02	2.80 ± 0.92 ^{b}
	***p*-value**		0.984	0.501	≤0.001	0.111	0.310	0.560	0.446	≤0.001
Types of complementary food pattern:										
homemade	257	55.0	2.05 ± 0.73	1.48 ± 0.52	3.59 ± 0.74	2.69 ± 0.81	2.98 ± 0.59	2.79 ± 0.59	2.55 ± 0.96	2.56 ± 0.88
commercial	210	45.0	2.04 ± 0.73	1.40 ± 0.49	3.48 ± 0.75	2.81 ± 0.93	2.84 ± 0.69	2.74 ± 0.63	2.64 ± 1.00	2.66 ± 0.92
	***p*-value**		0.923	0.079	0.113	0.408	0.011	0.477	0.434	0.203
Mealtime environment pattern:										
distracted	55	11.8	2.07 ± 0.67	1.51 ± 0.55	3.13 ± 0.71 ^{a}	3.02 ± 1.06 ^{a}	3.05 ± 0.65	2.97 ± 0.60 ^{a}	2.83 ± 1.07	2.97 ± 0.85 ^{a}
separated	115	24.6	2.05 ± 0.75	1.42 ± 0.47	3.33 ± 0.78 ^{a}	2.59 ± 0.83 ^{b}	2.94 ± 0.71	2.73 ± 0.64 ^{b}	2.51 ± 0.98	2.74 ± 0.99 ^{ab}
family	297	63.6	2.04 ± 0.74	1.44 ± 0.51	3.69 ± 0.70 ^{b}	2.75 ± 0.83 ^{ab}	2.88 ± 0.61	2.74 ± 0.59 ^{b}	2.58 ± 0.96	2.49 ± 0.84 ^{b}
	***p*-value**		0.816	0.568	≤0.001	0.035	0.157	0.026	0.189	≤0.001

^{a,b}—values with different superscript letters are significantly different ($p \leq 0.05$); FR—food responsiveness, EOE—emotional overeating, EF—enjoyment of food, DD—desire to drink, SR—satiety responsiveness, SE—slowness in eating, EUE—emotional undereating, FF—food fussiness; ABF—any breastfeeding; EBF—exclusive breastfeeding; Early feeding patterns: longer ABF—currently breastfed, EBF duration ~4.1 months, age at CFI ~5.6 months; formula—not currently breastfed, EBF duration ~0.3 months, age at CFI ~4.3 months; longer EBF—not currently breastfed, EBF duration ~5.4 months, age at CFI ~5.6 months; CFI—complementary feeding introduction; CF—complementary feeding; BLW—baby led weaning; TSF—tablespoon feeding.

Table 3. Multivariate regression analysis predicting eating behaviors.

Factors	CEBQ Subscales							
	FR β (95% CI)	**EOE β (95% CI)**	**EF β (95% CI)**	**DD β (95% CI)**	**SR β (95% CI)**	**SE β (95% CI)**	**EUE β (95% CI)**	**FF β (95% CI)**
Early feeding pattern:								
longer ABF	−0.169 (−0.273–0.064)	−0.035 (−0.139–0.069)	−0.107 (−0.207–−0.007) *	−0.187 (−0.289–−0.085) ***	0.117 (0.014–0.220) *	0.110 (0.006–0.214) *	0.045 (−0.060–0.149)	−0.024 (−0.126–0.079)
formula	0.044 (−0.059–0.147)	−0.043 (−0.146–0.060)	0.005 (−0.094–0.104)	0.114 (0.013–0.215) **	−0.018 (−0.120–0.084)	−0.084 (−0.187–0.019)	−0.036 (−0.140–0.068)	−0.016 (−0.118–0.085)
longer EBF	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
CF method:								
BLW	0.012 (−0.117–0.142)	−0.097 (−0.227–0.032)	0.026 (−0.098–0.151)	−0.090 (−0.218–0.037)	0.044 (−0.085–0.173)	−0.025 (−0.155–0.104)	−0.051 (−0.181–0.079)	−0.013 (−0.141–0.114)
mixed	0.018 (−0.094–0.131)	0.095 (−0.017–0.208)	0.083 (−0.025–0.190)	0.021 (−0.089–0.132)	−0.057 (−0.168–0.055)	−0.059 (−0.171–0.052)	0.014 (−0.099–0.126)	−0.124 (−0.234–−0.013) *
TSF	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Types of complementary food pattern:								
homemade	0.021 (−0.081–0.123)	0.108 (0.000–0.210)	−0.003 (−0.101–0.095)	−0.014 (−0.115–0.086)	0.118 (0.017–0.219)*	0.059 (−0.043–0.160)	−0.030 (−0.133–0.073)	0.002 (−0.099–0.103)
commercial	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Mealtime environment pattern:								
distracted	0.022 (−0.115–0.158)	0.092 (−0.044–0.229)	−0.212 (−0.343–−0.081) **	0.151 (0.018–0.285) *	0.122 (−0.013–0.257)	0.171 (0.035–0.307) *	0.125 (−0.012–0.262)	0.149 (0.015–0.284) **
separated	−0.015 (−0.149–0.119)	−0.071 (−0.205–0.064)	−0.068 (−0.197–0.061)	−0.226 (−0.357–−0.094) ***	0.010 (−0.123–0.143)	−0.101 (−0.234–0.033)	−0.121 (−0.255–0.014)	0.004 (−0.128–0.136)
family	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
R^2	0.01	0.01	0.09 ***	0.05 ***	0.03 **	0.02 *	0.00	0.04 ***

FR—food responsiveness, EOE—emotional overeating, EF—enjoyment of food, DD—desire to drink, SR—satiety responsiveness, SE—slowness in eating, EUE—emotional undereating, FF—food fussiness; CF—complementary feeding; Early feeding patterns: longer ABF—currently breastfed, EBF duration ~4.1 months, age at CFI ~5.6 months; formula—not currently breastfed, EBF duration ~0.3 months, age at CFI ~4.3 months; longer EBF—not currently breastfed, EBF duration ~5.4 months, age at CFI ~5.6 months; BLW—baby-led weaning; TSF—tablespoon feeding; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

Table 4. Adjusted regression analysis predicting eating behaviors.

Factors	CEBQ Subscales							
	FR β (95% CI)	**EOE β (95% CI)**	**EF β (95% CI)**	**DD β (95% CI)**	**SR β (95% CI)**	**SE β (95% CI)**	**EUE β (95% CI)**	**FF β (95% CI)**
Early feeding pattern:								
longer ABF	−0.197 (−0.307–0.087)	−0.029 (−0.139–0.082)	−0.178 (−0.282–−0.075) ***	−0.183 (−0.292–−0.074) **	0.158 (0.050–0.267) **	0.146 (0.037–0.255) **	0.064 (–0.047–0.175)	0.062 (−0.042–0.166)
formula	0.047 (−0.058–0.151)	−0.042 (–0.146–0.063)	0.018 (−0.080–0.116)	0.109 (0.006–0.212) *	−0.026 (−0.128–0.076)	−0.105 (−0.208–−0.002) *	−0.039 (−0.144–0.067)	−0.025 (−0.124–0.073)
longer EBF	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
CF method:								
BLW	0.013 (−0.117–0.143)	−0.100 (−0.231–0.030)	0.035 (−0.087–0.157)	−0.090 (−0.218–0.038)	0.036 (−0.092–0.163)	−0.036 (−0.164–0.093)	−0.056 (−0.187–0.075)	−0.017 (−0.139–0.105)
mixed	0.010 (−0.102–0.123)	0.095 (−0.018–0.208)	0.064 (−0.042–0.169)	0.022 (−0.089–0.133)	−0.044 (−0.155–0.066)	−0.052 (−0.163–0.059)	0.016 (−0.097–0.130)	−0.096 (−0.202–0.010)
TSF	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Types of complementary food pattern:								
homemade	0.025 (−0.077–0.127)	0.108 (0.000–0.210)	0.008 (−0.088–0.104)	−0.014 (−0.115–0.086)	0.110 (0.009–0.210) **	0.053 (−0.048–0.154)	−0.032 (−0.135–0.071)	−0.013 (−0.109–0.083)
commercial	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Mealtime environment pattern:								
distracted	0.030 (−0.107–0.166)	0.092 (−0.046–0.229)	−0.192 (−0.321–−0.064) **	0.150 (0.015–0.285) *	0.110 (−0.024–0.244)	0.160 (0.025–0.295) *	0.120 (−0.017–0.258)	0.125 (−0.004–0.253)
separated	−0.019 (−0.153–0.115)	−0.071 (−0.206–0.064)	−0.078 (−0.205–0.048)	−0.224 (−0.356– −0.092) ***	0.016 (−0.116–0.147)	−0.093 (−0.026–0.039)	−0.119 (−0.254–0.016)	0.018 (−0.109–0.144)
family	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
R^2	0.01	0.00	0.12 ***	0.04 **	0.05 ***	0.03 **	0.00	0.12 ***

FR—food responsiveness, EOE—emotional overeating, EF—enjoyment of food, DD—desire to drink, SR—satiety responsiveness, SE—slowness in eating, EUE—emotional undereating, FF—food fussiness; CF—complementary feeding; Early feeding patterns: longer ABF—currently breastfed, EBF duration ~4.1 months, age at CFI ~5.6 months; formula—not currently breastfed, EBF duration ~0.3 months, age at CFI ~4.3 months; longer EBF—not currently breastfed, EBF duration ~5.4 months, age at CFI ~5.6 months; BLW—baby-led weaning; TSF—tablespoon feeding; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$; model adjusted for children age, gender and maternal education.

Furthermore, in the multivariate model, longer ABF pattern turned out to be associated with lower scores on the EF subscale ($\beta = -0.107$, 95% CI: -0.207– -0.007, $p \leq 0.05$) and higher scores on the SE subscale ($\beta = 0.110$, 95% CI: 0.006–0.214, $p \leq 0.05$; Table 3) compared to longer EBF pattern. In the adjusted model, those results remained significant (EF $\beta = -0.178$, 95% CI: -0.282– -0.075, $p \leq 0.001$; SE $\beta = 0.146$, 95% CI: 0.037–0.255, $p \leq 0.01$; Table 4). In addition, formula feeding pattern turned out to be associated with lower reported SE ($\beta = -0.105$, 95% CI: -0.208– -0.002, $p \leq 0.05$; Table 4).

3.4.2. Complementary Feeding Method

Univariate analysis revealed significant differences between scores in EF and FF subscales and method of complementary feeding introduction (Table S5). Introducing solids with the BLW method was positively associated with a score on the EF subscale ($\beta = 0.112$, 95% CI: 0.003–0.222, $p \leq 0.05$), whereas using a mixed method was negatively associated with a score on the FF subscale ($\beta = -0.126$, 95% CI: -0.235– -0.016, $p \leq 0.05$), when compared to the tablespoon feeding method. In multivariate analysis, only association between mixed method and score on the FF subscale remained significant ($\beta = -0.124$, 95% CI: -0.234– -0.013, $p \leq 0.05$; Table 3). However, those associations were not observed in the adjusted model (Table 4).

3.4.3. Types of Complementary Food Pattern

Children who were fed more often with homemade foods scored significantly higher on the SR subscale in comparison to those who ate commercial baby foods more often. This association was observed in univariate ($\beta = 0.112$, 95% CI: 0.021–0.202, $p \leq 0.05$; Table S5), multivariate ($\beta = 0.118$, 95% CI: 0.017–0.219, $p \leq 0.05$; Table 3) and adjusted ($\beta = 0.110$, 95% CI: 0.009–0.210, $p \leq 0.01$; Table 4) models.

3.4.4. Mealtime Environment Pattern

Associations between mealtime environment pattern and scores on the EF, DD, SE and FF subscales were observed in univariate (Table S5) and multivariate (Table 3) analyses. Meal consumption during distraction was negatively associated with EF (univariate: $\beta = -0.240$, 95% CI: -0.368– -0.112, $p \leq 0.001$; multivariate: $\beta = -0.212$, 95% CI: -0.343– -0.081, $p \leq 0.01$) and positively associated with DD (univariate: $\beta = 0.185$, 95% CI: 0.053–0.317, $p \leq 0.01$; multivariate: $\beta = 0.151$, 95% CI: 0.018–0.285, $p \leq 0.05$), SE (univariate: $\beta = 0.178$, 95% CI: 0.045–0.310, $p \leq 0.01$; multivariate: $\beta = 0.171$, 95% CI: 0.035–0.307, $p \leq 0.05$) and FF (univariate: $\beta = 0.185$, 95% CI: 0.054–0.316, $p \leq 0.01$; multivariate: $\beta = 0.149$, 95% CI: 0.015–0.284, $p \leq 0.01$) subscales when compared to eating meals with family. Most of these results remained significant in the adjusted model, with the exception of FF subscale (Table 4). Moreover, meal consumption separately to family was associated negatively with scores on the DD subscale (univariate: $\beta = -0.191$, 95% CI: -0.323– -0.059, $p \leq 0.01$; multivariate: $\beta = -0.226$, 95% CI: -0.357– -0.094, $p \leq 0.001$; adjusted: $\beta = -0.224$, 95% CI: -0.356–-0.092, $p \leq 0.001$).

4. Discussion

This paper contributes to a growing number of studies about possible associations between nutrition in the first year and later eating behaviors. In this study, we found that early feeding factors, such as breastfeeding duration, age and method of complementary feeding introduction as well as types of complementary foods and mealtime environment may be related with eating behaviors, such as food responsiveness, enjoyment of food, desire to drink, satiety responsiveness, slowness in eating and food fussiness in children aged 1–3 years old. Results regarding subscales such as emotional over- and under-eating were not significant in all conducted analyses. We also noticed that from among sociodemographic and birth-related factors, only maternal education level, child's age and birthweight varied in results of the CEBQ questionnaire.

4.1. Early Feeding Pattern—Breastfeeding and Age at Complementary Feeding Introduction

In adjusted linear regression analysis, we found that children with a longer ABF pattern scored lower on the enjoyment in food subscale when compared to those with a longer EBF pattern. This suggests that when considering this subscale, longer exclusive breastfeeding is more important than longer duration of any breastfeeding. Similarly like on the EF subscale, children with a longer ABF pattern scored lower on the desire to drink subscale when compared to longer EBF pattern children. In addition, those with a formula pattern scored higher on the desire to drink subscale. We also found that children with a longer ABF pattern scored higher on the satiety responsiveness and slowness in eating subscales, when compared to the reference group. Moreover, children with a formula pattern scored lower on the slowness in eating subscale in comparison to the longer EBF group. These results, except for enjoyment of food, are consistent with other authors' findings, suggesting that longer breastfeeding duration may be related to lower desire to drink and higher satiety responsiveness and slowness in eating [8,20–23,53–55]. Admittedly, Mallan et al. [54] came to a contrary conclusion regarding satiety responsiveness, as in their study, formula-fed infants scored higher on this subscale than breastfed infants. Other authors also observed differences between breastfeeding and other subscales, such as FR (which we also found between mean scores on this subscale) and FF (inverse associations [8,21,24–26,53]) and EUE (positive association [8]). Nonetheless, some studies did not observe any differences [27,28].

Because with longer ABF and longer EBF patterns, age at complementary feeding introduction was very similar, the only difference between age at complementary feeding introduction was observed for the desire to drink and slowness in eating subscales (formula pattern). In the Albuquerque et al. study [56], slowness in eating was related to appetite restraint behavior, whereas desire to drink related to appetite disinhibition. However, in this study, any differences between breastfeeding duration or age at complementary feeding introduction were observed in the multivariate model. Nevertheless, in a recent study conducted by Vandyousefi et al. [55], authors observed that infants with higher slowness in eating scores had lower odds of early introduction to solids. In our study, children with a formula pattern scored lower on the slowness in eating subscale and they also had lower age at complementary feeding introduction (4.3 months), when compared to children with a longer EBF pattern, with a mean age of complementary feeding introduction of 5.6 months. Previously, other authors reported possible links between timing of complementary feeding introduction and food fussiness [21], food and satiety responsiveness [27] and enjoyment of food [27]; however, some studies observed no differences between these factors [26,56].

4.2. Method of Complementary Feeding Introduction

We found that children who followed a baby-led weaning method, as well as mixed method, scored higher on the enjoyment of food subscale, when compared to those children who had been introduced to solids with tablespoon method. Similarly to our results, Komninou et al. [57] reported that infants who were fed BLW, in comparison with those who were parent-fed, had higher levels of food enjoyment. Additionally, in Taylor et al. [30], authors found that mothers of infants who were introduced to solids with the BLISS method reported positive attitude on this subscale. In addition, according to mothers who used BLW or mixed method, their children scored lower on the food fussiness subscale, when compared to those who introduced solids with the tablespoon method. These findings are consistent with results from other studies [29,30,57].

Furthermore, other authors observed that BLW might be associated with lower scores on the food responsiveness subscale [21], however, results regarding satiety responsiveness are inconclusive [21,30].

4.3. Types of Complementary Foods

We found that infants who ate homemade complementary foods more often during the first 3 months of eating solids had a higher satiety response than those who ate commercial baby foods more often. Unfortunately, to the best of our knowledge, the number of studies regarding associations between types of complementary foods and eating behaviors in children is scarce. In the Albuquerque et al. study [56], satiety responsiveness was related to appetite restraint behaviors and authors noticed that children who ate cereals, porridge or fruit as their first solid reported more appetite restraint behaviors at 7 years old than children who received soup as their first food. Nevertheless, these data should not be directly compared to our findings as there are differences in methods between our studies.

4.4. Mealtime Environment

Another finding from our study is that children who followed a distracted mealtime environment pattern had lower scores on the enjoyment of food subscale when compared to those who followed the family pattern (reference group). Furthermore, they also scored higher on the desire to drink and slowness in eating subscales, when compared to the reference group. In addition, toddlers with the separated mealtime environment pattern scored lower in desire to drink subscale, when compared to the reference group. These findings were observed in the adjusted regression analysis model. In addition, when comparing mean scores on the subscales between patterns, differences were also observed on the food fussiness subscale—children with a distracted pattern scored higher in comparison to those with a family pattern.

The same direction of observed eating behaviors was reported by Finnane et al. [18]. In their study, parents who used family meal setting practice reported higher enjoyment of food and lower food fussiness in their children. Additionally, other studies also revealed that family meals were associated with lower food fussiness [25,58]. In the Finnane et al. study [18], authors used different tools in their assessment of mealtime habits, so our results should not be directly compared; however, they also observed that parents who used persuasive feeding practices reported higher slowness in eating, food fussiness, desire to drink and lower enjoyment of food, which is in line with our observations with the distracted pattern. Similar findings were observed in other studies, where maternal pressure to eat practices were positively associated with child pickiness [32], food fussiness [31,59–61], desire to drink [59], slowness in eating [60,61] and negatively related to enjoyment of food [59–61]. Overall, this may suggest that types of mealtime environment when baby is distracted or pressured may be related to lower enjoyment of food and higher desire to drink, slowness in eating and food fussiness, as opposed to the family mealtime environment.

Inconsistency between ours and other authors' results could be due to the different methods applied in the studies. Mallan et al. [54] used another tool in the assessment of children's behaviors (Baby Eating Behavior Questionnaire). Additionally, in studies regarding mealtime environment, authors often used the Child Feeding Questionnaire to measure maternal practices [31,32,59,61]; nonetheless, despite this difference, the direction of observed associations is in line with ours. In addition, children's age at assessment could also affect differences in obtained results (from 17 ± 3 weeks [54] up to 9 years [28]) and in a study conducted by Vandyousefi et al. [62], authors found low to moderate stability for selected appetite traits measured over time.

4.5. Possible Mechanisms

Potential mechanisms underlying possible associations between analyzed factors and eating behaviors may arise from the fact that breastfeeding, through numerous pathways, may be related with eating behaviors. Those mechanisms include maternal milk composition [63] and flavor learning [64], as well as the infant-led nature of breastfeeding, which may promote eating self-regulation [20,65]. Moreover, breastfeeding mothers may be more vigilant for satiety and hunger signals communicated by their infants [23,65,66].

Possible explanation of observed differences between complementary feeding method and eating behaviors is that parents who use BLW/mixed method usually start complementary feeding later than those who use traditional method [14,67] and Schwartz et al. [68] observed that between 5 and 7 months infants' reactions to new foods were mostly positive.

In addition, in BLW/mixed method, infants are usually introduced earlier to complex texture of solids, which can be a protective factor against food fussiness as later introduction to lumpy foods was related to feeding difficulties [69]. Interestingly, in a study conducted by Brown and Lee [21], authors noticed that the relationship between BLW and food fussiness diminished after accounting for maternal control, which suggests that a wider acceptance of foods in BLW infants may be explained by a lower level of maternal control.

The possible influence of types of complementary foods could be partially explained by differences in the nutritional quality of homemade and commercial products. According to WHO reports [15,16], commercial baby foods may have an inadequate nutritional quality, such as high content of sugars and low energy density. On the other hand, homemade meals may be more balanced and, thus, improve satiety responsiveness. Additionally, as we observed, children who were breastfed longer scored higher in satiety responsiveness. Thus, association with homemade foods can be also explained by Foterek et al. [70] findings, as they observed that children who consumed commercial foods more often showed shorter breastfeeding duration.

As noticed by Webber et al. [61], pleasant mealtime environment (with lower maternal pressure to eat) may contribute to a child's enjoyment in eating, which may partially explain our observations. Higher observed scores on the food fussiness subscale in children with a distracted pattern may be supported by the findings of Finnane et al. [18] who noticed that enjoyment of food and food fussiness were inversely related. Additionally, children who are distracted during mealtime may not have a chance to create desirable eating habits, as opposed to children who eat meals with other family members [7].

4.6. Strengths and Limitations

One of the strengths of the present study is the fact that we used a validated tool to assess children's eating behaviors. Moreover, we took a few factors into account that gave us a broader image of possible associations between early feeding factors and children's eating behaviors. The internet-based nature of the study ensures equal access to participate in the study for respondents from diverse regions and backgrounds. This study is also strengthened by its large sample size.

Nonetheless, our work clearly has some limitations. First, as the study was conducted among internet users, there is a possibility that more mothers who were interested in children's nutrition were involved, so self-selection bias could have occurred (especially as we observed a relatively high percentage of exclusive breastfeeding for 6 months and complementary feeding after 4 months). Second, we asked mothers about factors related to early childhood, so memory bias could occur. Nevertheless, the recall time in our study was less than 3 years, which minimized the risk of recall bias [71,72]. Third, the study sample was characterized by an educational level that was higher than the national average; however, this could be due to the observed steady increase in the number of mothers with higher education (40% in 2010 and 50% in 2017 [73]). Moreover, in our future studies, we plan to focus on possible links between BMI, dietary habits and eating behaviors, as it was not the purpose of the present study, so we could not discuss obtained results in a broader context. In addition, not every observed difference between mean scores in given subscales was confirmed in the regression analysis, thus further studies are needed. Finally, admittedly, the original structure of the CEBQ was confirmed in a study that involved older children [34]; however, this questionnaire has also previously been used among younger children [20,30,39,74,75].

5. Conclusions

Taken together, our findings suggest that early feeding factors such as breastfeeding duration, types of complementary foods as well as mealtime environment in the first months of complementary feeding may be related to eating behaviors among children aged 1–3 years old, such as enjoyment of food, desire to drink, satiety responsiveness and slowness in eating.

Our findings should be considered in the context of possible implications. Eating behaviors in infancy and childhood may be an important factor in creating desirable eating habits that can be further transmitted into adulthood. Taking into account our results, parents of toddlers should receive information about the importance of breastfeeding and responsive feeding, as well as advice on how to create a mealtime environment which fosters shaping healthy eating habits. This seems to be very important, especially as some works suggest possible links between CEBQ subscales and BMI/weight status [38,59,76,77] or diet variety [78].

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/nu14112279/s1; Table S1: Component variables in k-means analysis—early feeding pattern; Table S2: Component variables in k-means analysis—types of complementary food pattern; Table S3: Component variables in k-means analysis—mealtime environment pattern; Table S4: Birth-related factors, maternal BMI and ever formula feeding according to CEBQ results; Table S5: Univariate regression analysis predicting eating behaviors.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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Early Feeding Factors and Eating Behaviors Among Children Aged 1-3: A Cross-Sectional Study

Daria Masztalerz-Kozubek, Monika A. Zielinska-Pukos* and Jadwiga Hamulka

Table S1. Component variables in k-means analysis – early feeding pattern.

Variable	Early feeding pattern (%)			p-value
	Longer ABF (n=174)	Formula (n=160)	Longer EBF (n=133)	
Current breastfeeding:	yes 100%	no 100%	no 100%	≤0.001
EBF duration (months):				
never BF/EBF <1	23.0	85.0	0.0	
1-4	13.2	15.0	21.0	≤0.001
5-7	63.8	0.0	79.0	
Age at CFI (months):				
<4	2.9	29.4	1.5	
4-6	86.8	69.4	88.7	≤0.001
≥ 7	10.3	1.2	9.8	

ABF – any breastfeeding; BF – breastfeeding; EBF – exclusive breastfeeding; CFI – complementary feeding introduction

Table S2. Component variables in k-means analysis – types of complementary food pattern.

Frequency of consumption of selected foods during the first 3 months of complementary feeding	Types of complementary food pattern (%)		p-value
	Homemade (n=257)	**Commercial** (n=210)	
Commercial soup/dinner jars:			
never or almost never	56.9	1.9	
once a month or less	20.2	2.9	
few times per month	20.2	21.4	
few times per week	2.3	45.7	≤0.001
everyday	0.4	25.2	
few times per day	0.0	2.9	
I don't remember	0.0	0.0	
Commercial baby cereals:			
never or almost never	67.7	11.4	
once a month or less	15.2	6.2	
few times per month	10.5	18.1	
few times per week	4.7	40.0	≤0.001
everyday	1.9	22.4	
few times per day	0.0	1.9	
I don't remember	0.0	0.0	
Commercial fruit jars:			
never or almost never	40.8	2.4	
once a month or less	21.4	1.9	
few times per month	25.7	22.9	
few times per week	11.7	49.0	≤0.001
everyday	0.4	20.9	
few times per day	0.0	2.4	
I don't remember	0.0	0.5	
Commercial baby juices/bevereges:			
never or almost never	0.4	7.6	
once a month or less	0.8	5.2	
few times per month	0.4	1.9	
few times per week	0.0	1.0	≤0.001
everyday	0.0	0.5	
few times per day	95.3	79.0	
I don't remember	3.1	4.8	
Commercial tea for babies:			
never or almost never	98.8	89.0	
once a month or less	0.4	1.9	
few times per month	0.8	4.8	
few times per week	0.0	2.9	≤0.001
everyday	0.0	0.9	

few times per day	0.0	0.5	
I don't remember	0.0	0.0	

Table S2. Component variables in k-means analysis – types of complementary food pattern – *cont.*

Frequency of consumption of selected foods during the first 3 months of complementary feeding	**Types of complementary food pattern (%)**		**p-value**
	Homemade (n=257)	**Commercial** (n=210)	
Homemade meals cooked especially for baby:			
never or almost never	15.9	6.7	
once a month or less	9.3	3.8	
few times per month	19.5	13.8	
few times per week	17.9	37.6	≤0.001
everyday	23.4	29.0	
few times per day	13.6	8.1	
I don't remember	0.4	1.0	
Family meals adjusted for baby:			
never or almost never	2.7	11.4	
once a month or less	1.6	6.2	
few times per month	5.8	19.1	
few times per week	15.6	32.9	≤0.001
everyday	37.0	24.3	
few times per day	34.2	5.2	
I don't remember	3.1	0.9	
Family meals not adjusted for baby:			
never or almost never	77.4	73.8	
once a month or less	10.9	13.8	
few times per month	6.2	5.7	
few times per week	2.7	3.3	0.930
everyday	1.2	1.0	
few times per day	0.4	1.0	
I don't remember	1.2	1.4	

Table S3. Component variables in k-means analysis – mealtime environment pattern.

Frequency of meals consumption in a given way	Mealtime environment pattern (%)			p-value
	Distracted (n=55)	**Separate** (n=115)	**Family** (n=297)	
In the same time than other family members:				
never or almost never	3.6	22.6	0.0	
occasionally	34.6	70.4	0.3	
often	38.2	5.2	39.1	≤0.001
always/almost always	21.8	0.0	60.6	
I don't remember	1.8	1.8	0.0	
Separately from other family members:				
never or almost never	10.9	1.7	18.9	
occasionally	34.6	4.4	66.0	
often	52.7	60.9	13.8	≤0.001
always/almost always	1.8	33.0	0.3	
I don't remember	0.0	0.0	1.0	
During watching TV:				
never or almost never	52.7	87.0	94.3	
occasionally	30.9	11.3	4.7	
often	12.7	1.7	1.0	≤0.001
always/almost always	3.7	0.0	0.0	
I don't remember	0.0	0.0	0.0	
When distracted:				
never or almost never	0.0	91.3	97.6	
occasionally	70.9	8.7	2.4	
often	29.1	0.0	0.0	≤0.001
always/almost always	0.0	0.0	0.0	
I don't remember	0.0	0.0	0.0	
During playtime:				
never or almost never	36.4	91.3	89.2	
occasionally	40.0	4.3	9.4	
often	23.6	2.6	1.4	≤0.001
always/almost always	0.0	0.9	0.0	
I don't remember	0.0	0.9	0.0	
During sleeping:				
never or almost never	89.1	95.7	99.0	
occasionally	7.3	2.6	0.7	
often	3.6	1.7	0.3	0.002
always/almost always	0.0	0.0	0.0	

I don't remember	0.0	0.0	0.0	
Until child's finished meal:				
never or almost never	60.0	88.7	94.0	
occasionally	25.5	7.8	4.7	
often	9.1	3.5	0.3	≤0.001
always/almost always	3.6	0.0	0.3	
I don't remember	1.8	0.0	0.7	

Table S4. Birth-related factors, maternal BMI and ever formula feeding according to CEBQ results.

Variable	n	%	CEBQ subscales							
			FR	EOE	EF	DD	SR	SE	EUE	FF
Pregnancy duration:										
preterm	42	9.0	1.88 ± 0.63	1.49 ± 0.59	3.39 ± 0.79	2.62 ± 0.72	3.11 ± 0.83	2.64 ± 0.62	2.75 ± 1.10	2.73 ± 0.87
term	425	91.0	2.06 ± 0.74	1.44 ± 0.50	3.55 ± 0.74	2.76 ± 0.88	2.90 ± 0.62	2.78 ± 0.61	2.57 ± 0.97	2.60 ± 0.90
p-value			0.123	0.856	0.276	0.440	0.114	0.135	0.364	0.446
Birthweight to gestational age:										
SGA	17	3.6	1.99 ± 0.58	1.54 ± 0.63	3.50 ± 0.94	2.90 ± 0.77	3.25 ± 0.62	2.93 ± 0.60	2.90 ± 1.02	2.46 ± 0.80
AGA	360	77.1	2.05 ± 0.75	1.45 ± 0.52	3.54 ± 0.76	2.71 ± 0.88	2.91 ± 0.64	2.75 ± 0.62	2.56 ± 0.99	2.63 ± 0.91
LGA	90	19.3	2.06 ± 0.69	1.39 ± 0.43	3.54 ± 0.69	2.86 ± 0.83	2.88 ± 0.66	2.79 ± 0.57	2.64 ± 0.95	2.56 ± 0.87
p-value			0.961	0.654	0.929	0.204	0.133	0.525	0.305	0.727
Birthweight (g):										
< 2500	23	4.9	1.64 ± 0.45[a]	1.39 ± 0.45	3.21 ± 0.70	2.78 ± 0.76	3.17 ± 0.73	2.62 ± 0.64	2.85 ± 1.14	2.64 ± 0.91
2500-3999	401	85.9	2.07 ± 0.75[b]	1.46 ± 0.52	3.56 ± 0.75	2.75 ± 0.88	2.91 ± 0.64	2.76 ± 0.61	2.57 ± 0.97	2.61 ± 0.90
≥ 4000	43	9.2	2.02 ± 0.65[ab]	1.36 ± 0.40	3.51 ± 0.69	2.68 ± 0.76	2.81 ± 0.57	2.90 ± 0.59	2.60 ± 0.98	2.54 ± 0.86
p-value			0.016	0.643	0.092	0.904	0.151	0.118	0.589	0.886
Maternal BMI:										
< 18.5	33	7.1	2.09 ± 0.78	1.56 ± 0.66	3.56 ± 0.65	2.71 ± 0.79	3.03 ± 0.52	2.80 ± 0.55	2.39 ± 0.95	2.63 ± 0.84
18.5-24.9	286	61.2	2.01 ± 0.73	1.42 ± 0.50	3.53 ± 0.75	2.72 ± 0.86	2.92 ± 0.65	2.77 ± 0.58	2.63 ± 0.99	2.64 ± 0.92
25-29.9	97	20.8	2.08 ± 0.76	1.47 ± 0.49	3.54 ± 0.77	2.79 ± 0.92	2.86 ± 0.64	2.75 ± 0.65	2.62 ± 1.00	2.59 ± 0.86
≥ 30	51	10.9	2.13 ± 0.64	1.43 ± 0.47	3.54 ± 0.78	2.80 ± 0.89	2.93 ± 0.65	2.74 ± 0.71	2.44 ± 0.89	2.45 ± 0.86
p-value			0.486	0.641	0.999	0.840	0.498	0.929	0.425	0.659
Ever formula feeding:										
no	269	57.6	2.05 ± 0.75	1.46 ± 0.51	3.53 ± 0.73	2.72 ± 0.88	2.95 ± 0.63	2.78 ± 0.61	2.59 ± 0.97	2.65 ± 0.90

yes	198	42.4	2.04 ± 0.72	1.42 ± 0.50	3.58 ± 0.77	2.79 ± 0.85	2.86 ± 0.66	2.74 ± 0.61	2.59 ± 1.02	2.52 ± 0.87
p-value			0.950	0.419	0.372	0.362	0.233	0.484	0.965	0.144

[a,b] – values with different superscript letters are significantly different (p≤0.05); FR – food responsiveness, EOE – emotional overeating, EF – enjoyment of food, DD – desire to drink, SR – satiety responsiveness, SE – slowness in eating, EUE – emotional undereating, FF – food fussiness; SGA – small for gestational age; AGA – appropriate for gesta- tional age; LGA – large for gestational age; BMI – body mass index

Table S5. Univariate regression analysis predicting eating behaviors.

Factors	CEBQ subscales							
	FR β (95% CI)	**EOE** β (95% CI)	**EF** β (95% CI)	**DD** β (95% CI)	**SR** β (95% CI)	**SE** β (95% CI)	**EUE** β (95% CI)	**FF** β (95% CI)
Early feeding pattern:								
longer ABF	-0.160 (-0.260– -0.060)**	-0.031 (-0.132–0.071)	-0.046 (-0.147–0.055)	-0.194 (-0.294– -0.094)***	0.120 (0.019–0.221)	0.097 (-0.005–0.198)	0.030 (–0.071–0.132)	-0.067 (-0.168–0.034)
formula	0.038 (-0.063–0.138)	-0.052 (-0.153–0.049)	-0.047 (-0.148–0.054)	0.119 (0.019–0.219)*	-0.022 (-0.123–0.079)	-0.074 (-0.175–0.027)	-0.022 (-0.124–0.079)	0.019 (-0.082–0.120)
longer EBF	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
R^2	0.02**	0.01	0.01	0.03***	0.01	0.01	0.00	0.00
CF method:								
BLW	-0.015 (-0.126–0.097)	-0.056 (-0.167–0.056)	0.112 (0.003–0.222)*	-0.108 (-0.219–0.003)	0.077 (-0.034–0.189)	0.003 (-0.108–0.114)	-0.057 (-0.168–0.054)	-0.076 (-0.186–0.034)
mixed	0.016 (-0.096–0.127)	0.074 (-0.037–0.186)	0.083 (-0.027–0.193)	0.007 (-0.104–0.118)	-0.076 (-0.187–0.035)	-0.078 (-0.189–0.033)	0.007 (-0.104–0.118)	-0.126 (-0.235– -0.016)*
TSF	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
R^2	0.00	0.00	0.03***	0.01	0.00	0.00	0.00	0.03***
Types of complementary food pattern:								
homemade	0.008 (-0.083–0.100)	0.076 (-0.015–0.167)	0.070 (-0.020–0.161)	-0.067 (-0.158–0.024)	0.112 (0.021–0.202)*	0.040 (-0.051–0.131)	-0.046 (-0.137–0.045)	-0.056 (-0.147–0.035)
commercial	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
R^2	0.00	0.00	0.00	0.00	0.010*	–0.00	0.00	0.00

Mealtime environment pattern:								
distracted	0.015 (-0.119–0.148)	0.076 (-0.057–0.209)	-0.240 (-0.368– -0.112)***	0.185 (0.053–0.317)**	0.103 (-0.030–0.236)	0.178 (0.045–0.310)**	0.137 (0.000–0.270)	0.185 (0.054–0.316)**
separated	0.000 (-0.133–0.133)	-0.059 (-0.192–0.074)	-0.057 (-0.185–0.070)	-0.191 (-0.323– -0.059)**	-0.020 (-0.153–0.112)	-0.116 (-0.248–0.016)	-0.115 (-0.248–0.017)	0.004 (-0.127–0.135)
family	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
R^2	0.00	0.00	0.08***	0.02*	0.00	0.01*	0.00	0.03***

FR – food responsiveness, EOE – emotional overeating, EF – enjoyment of food, DD – desire to drink, SR – satiety responsiveness, SE – slowness in eating, EUE – emotional under- eating, FF – food fussiness; CF – complementary feeding; Early feeding patterns: longer ABF – currently breastfed, EBF duration ~4.1 months, age at CFI ~5.6 months; formula – not currently breastfed, EBF duration ~0.3 months, age at CFI ~4.3 months; longer EBF – not currently breastfed, EBF duration ~5.4 months, age at CFI ~5.6 months; BLW – baby-led weaning; TSF – tablespoon feeding; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$

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The influence of early and current feeding practices, eating behaviors, and screen time on dietary patterns in Polish toddlers - A cross-sectional study

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ABSTRACT

Early nutrition has an important influence on a child's proper health and development, and understanding factors that may be related to desirable dietary patterns is key to improving the diet of future generations. The aim of this study was to assess whether early and current feeding practices, eating behaviors, and screen time viewing are associated with toddlers' dietary patterns. A cross-sectional sample of 467 mothers of toddlers (aged 1 year to 3) was surveyed between 2020 and 2022. Food consumption was evaluated by the Food Frequency Questionnaire (FFQ). The k-means algorithm was used to define dietary patterns on the basis of data collected from the FFQ and mealtime environment patterns, based on the data about practices during meals consumption. The odds of following a prohealth dietary pattern among early feeding factors were lower when infants ate commercial complementary foods more often. Distracted mealtime environment pattern increased the odds of following a non-eaters pattern, and commercial complementary foods pattern increased the odds of following a processed pattern. Currently, the odds of following a processed dietary pattern were higher when children were not breastfed and had higher screen time. Toddlers who ate during distraction and were more fussy had lower odds of following a prohealth dietary pattern, whereas higher enjoyment of food and satiety responsiveness increased the odds. The results indicate the need to increase parents' awareness about the importance of early factors in establishing dietary patterns.

1. Introduction

Dietary patterns, food repertoire, and eating behaviors acquired in the first years may track into childhood and beyond, and thus influence later food choices (Ares et al., 2023; Farrow & Blissett, 2012; Haines et al., 2019; Mikkilä et al., 2005; Nicklaus, 2009; Nicklaus et al., 2005; Nicklaus & Remy, 2013; Rose et al., 2017). Therefore, optimal nutrition in early life is an important determinant of a child's health and development and may impact further dietary habits (Hamulka et al., 2020; Manohar et al., 2021; Nicklaus & Remy, 2013; Schwartz et al., 2011; Schwarzenberg & Georgieff, 2018). Rose et al. (Rose et al., 2017) have observed that infants who had a dietary pattern higher in fruits and vegetables or followed a dietary pattern characterized by foods high in energy density had a higher intake of these products at the age of 6 years. Moreover, in a 21-year follow-up study, authors observed tracking of dietary patterns and food choices, suggesting that childhood diet may determine adult diet even after 21 years (Mikkilä et al., 2004, 2005). Nonetheless, in a study from the United States, the authors did not find a significant association between early life feeding practices and dietary patterns at the age of 10 (Sitarik et al., 2021).

Previous studies have shown an association between breastfeeding and dietary patterns and intake, which suggests the important role of breastfeeding in healthy eating in toddlerhood and beyond (Abraham et al., 2012; Grieger et al., 2011; Hamulka et al., 2020; Jackson & Johnson, 2017; Jones et al., 2015; Kheir et al., 2021; Kim & Shin, 2022; Scott et al., 2012; Vieira et al., 2019). Less is known about associations between type of solid foods (commercial/homemade) and later dietary patterns. Moreover, these studies regarded fruit and vegetable intake or variety as the outcome and results are inconsistent. In one study, at 12 months of age infants fed with commercial meals got a higher vegetable variety vs those fed with homemade meals (Mesch et al., 2014). In another study, higher percentage of commercial complementary food was associated with lower vegetable intake in infancy (both in girls and boys) and lower fruit and vegetable intake in preschool and school age

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(observed in boys), but no association with fruit and/or vegetable variety was found (Foterek et al., 2015).

Besides nutritional aspects, factors such as mealtime practices and lifestyle components, like screen time viewing are also likely to be associated with dietary outcomes in children and adolescents (da Costa et al., 2022; Domingues-Montanari, 2017; Haines et al., 2019; Hillesund et al., 2021; Reicks et al., 2019; Robson et al., 2020; Sandvik et al., 2019; Shqair et al., 2019; Snuggs & Harvey, 2023; Stiglic & Viner, 2019; Tambalis et al., 2020; Verhage et al., 2018; Vilela et al., 2018). Greater family meal frequency may be related to a more balanced diet, healthy eating index, and higher fruits and vegetables intake (Hillesund et al., 2021; Robson et al., 2020; Verhage et al., 2018), whereas eating alone has been linked with having less healthy dietary intake (Reicks et al., 2019). Excessive screen time exposure has been associated with adverse effects on children's development, cognitive abilities, and sleep (Domingues-Montanari, 2017; Stiglic & Viner, 2019), which is why the World Health Organization recommends no sedentary screen time for 1-year--olds and less than 1 h for children aged 2–3 years (WHO, 2019). Additionally, excessive screen time can be related to obesity and poor dietary outcomes (Domingues-Montanari, 2017; Shqair et al., 2019; Stiglic & Viner, 2019; Tambalis et al., 2020). However, fewer studies focused on toddlers as most of them were characterized by wide age range of study subjects, from 2 up to 18 years old (Dallacker et al., 2018; Hammons & Fiese, 2011; Hillesund et al., 2021; Reicks et al., 2019; Robson et al., 2020; Shqair et al., 2019; Tambalis et al., 2020; Verhage et al., 2018).

Children's eating behaviors may also influence their dietary intake. Higher food fussiness in infants and toddlers was related to a lower increase in vegetable intake during a learning trial (Caton et al., 2014). Increasing diet variety (from 4 to 7 years of age) was inversely associated with desire to drink, food fussiness, and satiety responsiveness subscales and positively with enjoyment of food (Vilela et al., 2018). Moreover, children with higher diet quality at the age of 7 scored lower in food fussiness and satiety responsiveness subscale 3 years later (da Costa et al., 2022). In addition, 5-year-old children with higher picky eating measured with the CEBQ consumed less vegetables, but not other food groups (Sandvik et al., 2019). However, less is known about these associations in younger children.

Feeding and mealtime practices, eating behaviors, and screen time viewing in the first years seem to be important determinants of dietary patterns. Considering the role of diet in the development of obesity and non-communicable diseases (Budreviciute et al., 2020), it is essential to understand factors that may influence and establish healthy eating patterns early in life. Each of these factors (breastfeeding, complementary feeding, mealtime environment, eating behaviors, and screen time) may affect dietary outcomes around the same time and none of the studies have yet looked at these factors simultaneously. Most of previous studies have investigated the above factors separately or were limited only to early feeding practices (Abraham et al., 2012; Barbosa et al., 2022; Hillesund et al., 2021; Kheir et al., 2021; Morison et al., 2018; Scott et al., 2012; Vieira et al., 2019). To the best of our knowledge, this is the first study to examine all of these factors (breastfeeding, type of complementary foods, mealtime environment, eating behaviors and screen time) concurrently. Thus, the aim of this study was to check possible links between early (exclusive breastfeeding duration, complementary foods and mealtime environment patterns) and current (breastfeeding, mealtime environment pattern, eating behaviors, screen time) factors and dietary patterns in children aged 1–3 years old. We hypothesized that desirable feeding practices both in the first and last 3 months (longer breastfeeding, homemade complementary foods patterns, eating meals with family) would be related with a positive dietary pattern. Undesirable feeding practices (shorter breastfeeding, commercial complementary foods pattern, eating meals during distraction or separately) and screen time exposure, on the other hand, would be related with a negative dietary pattern. At the same time, eating behaviors, measured by the CEBQ, would also show associations with dietary patterns. As well we assumed that the strength of early and current feeding practices may not be equal.

2. Materials and methods

2.1. Study design and participants

The study was a cross-sectional study of Polish children aged 1–3 years old conducted in 2020–2022 with the use of the CAWI (Computer-Assisted Web Interview) method. The project was reviewed and approved by the Ethics Committee of the Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences (resolution no. 45/2019) and followed the ethical standards recognized by the Declaration of Helsinki. All data were collected anonymously. Detailed study design, methods, and sample selection data have been previously published (Masztalerz-Kozubek et al., 2022).

The link to the online survey was published on social media (mainly on Facebook, and Instagram, also was shared by personal contacts of the research group members). Mothers were informed about the scientific purpose of the study, its anonymity, voluntary, and the possibility of resigning from the participation at any stage. A total of 603 mothers completed the online survey. Some of them were excluded from the final analysis due to: toddlers outside the age range (n = 45), missing or incomplete data about early feeding (n = 46) or maternal anthropometry (n = 6), living abroad (n = 37), and gestational age lower than 23 weeks/higher than 44 weeks (n = 2). 467 of them were included in the final analysis (Fig. 1).

2.2. Questionnaire

The questionnaire consisted of questions regarding early and current feeding practices, eating behaviors, children and maternal anthropometry, birth-related data, toddlers' health and development, and sociodemographic data.

2.2.1. Early feeding practices

We gathered information about milk feeding practices (breastfeeding/formula feeding), types of complementary foods (homemade/commercial), and mealtime environment in the first 3 months of complementary feeding (consuming meals with family/separately/during distraction, such as watching TV or during playtime). Based on this data, in our previous paper (Masztalerz-Kozubek et al., 2022) we created two patterns regarding type of consumed complementary foods, and mealtime environment. First – complementary foods pattern, where two clusters were selected: homemade (presented by 55.0% of study population), characterized by more frequent consumption of family foods adjusted for babies, and homemade meals cooked especially for babies, and commercial (45.0%), characterized by more frequent consumption of commercial baby foods. Second – mealtime environment pattern in the first 3 months with three clusters: distracted (11.8%), where infants ate more often during distraction; separated (24.6%), in which infants ate more often at different times than the rest of family members and family (63.6%), characterized by more frequent meals with other family members (Masztalerz-Kozubek et al., 2022).

2.2.2. Current feeding practices and eating behaviors

In order to investigate current feeding practices, mothers were asked to relate to the last 3 months of children's nutrition. Information about frequency of consumption of 23 food items was collected according to the following categories: (1) never or almost never, (2) less than once per week, (3) 1 time per week, (4) at least 2–4 times per week, (5) 1 time per day, (6) several times per day, using the adapted Food Frequency Questionnaire (FFQ) (Masztalerz-Kozubek et al., 2020; Wądołowska & Niedźwiedzka). Additionally, we asked about the mealtime environment in the last 3 months (frequency of meal consumption with family, peers, separately, during watching TV, distraction, playtime). To assess parental perceptions of their child's eating, mothers were asked to

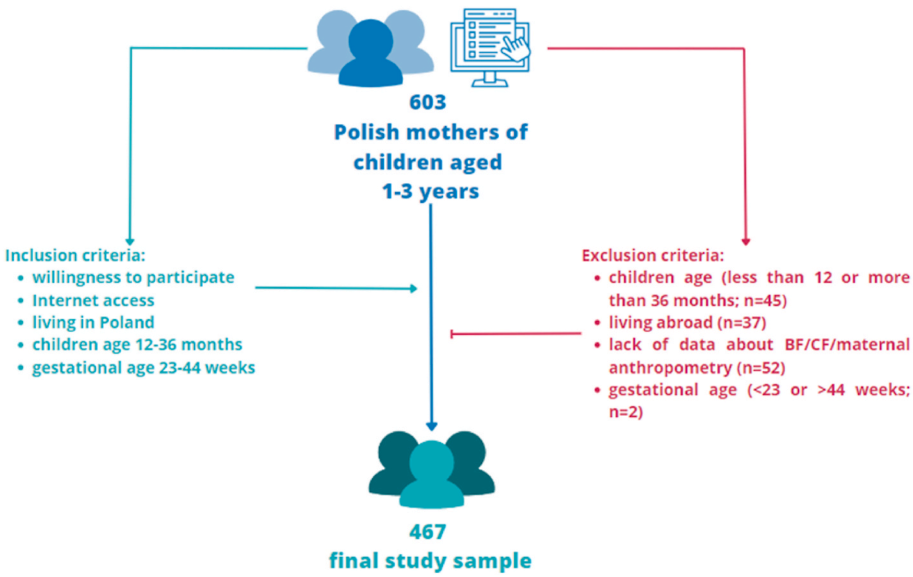

Fig. 1. Flowchart of the study population. BF – breastfeeding; CF – complementary feeding.

complete the Children's Eating Behavior Questionnaire (CEBQ) which is a 35-item tool (Wardle et al., 2001). CEBQ contained the original eight eating behaviors subscales that represent four food approach behaviors (food responsiveness (FR), enjoyment of food (EF), emotional overeating (EOE), and desire to drink (DD)) and four food avoidance behaviors (satiety responsiveness (SR), food fussiness (FF), slowness in eating (SE) and emotional undereating (EUE)). The questionnaire has been used and validated in a population of Polish children (Czepczor--Bernat & Brytek-Matera, 2019; Malczyk et al., 2022) as well as in our study population. Originally, mothers rated each of the 35 items on a 5-point Likert scale, ranging from *never* to *always*, where higher scores reflect a higher intensity of the specific eating behaviors. The scores for 5 of the opposite phrasing items were reversed. However, in our analysis two items were eliminated (*My child finishes his/her meal quickly* from the SE subscale and *My child eats more when s/he has nothing else to do* from the EOE subscale) what increased internal consistency measured with Cronbach's alpha reliability for these subscales.

2.2.3. Toddlers' health, development and lifestyle

Mothers were asked about toddlers' health conditions, sleep duration, maternal concerns about children's weight, and whether toddlers attend daycare/preschool. We also asked about screen time, which was formulated as how much during the day a toddler uses a smartphone or tablet or watches TV. We gathered data according to the following categories: (1) child doesn't use such devices, (2) less than 30 min, (3) 30–60 min, (4) 60–120 min, (5) more than 120 min. Due to the small number of answers obtained in some categories, we aggregated them as follows: (1) child doesn't use such devices, (2) less than 30 min, (3) 30–60 min, (4) more than 60 min.

2.2.4. Sociodemographic and lifestyle data

We collected data about parental age and education level, living area (size of place of residence and region of the country, further categorized according to the percentage of EU-27 average gross domestic product (GDP) per capita), number of adults and children living in the household. We also asked about children's sex, age, and birth outcomes (e.g. pregnancy duration, birth anthropometry), maternal weight and height (used to calculate BMI) and smoking status. The socioeconomic and lifestyle status (SLES) was calculated as the sum of the values assigned to the response categories for each of the ten single SLES factors (Supplementary Table 1). The sum of points was calculated, and the tertiles of the SLES were then created. Potential confounders were preselected based on the current understanding of common and possible factors influencing children's diets (Fernández-Alvira et al., 2014; Francis et al., 2001; Koivuniemi et al., 2022; Moore et al., 2023; Rasmussen et al., 2006; Rogers & Emmett, 2003; Santos et al., 2016; Sotos-Prieto et al., 2015).

2.3. Statistical analysis

For nominal variables, results were presented as a percentage, and chi-square test was performed. Comparisons of quantitative variables were performed using the U Mann-Whitney test due to non-parametric distribution (confirmed by using the Shapiro-Wilk test) and were summarized by means and standard deviations (SD).

Mealtime environment pattern in the last 3 months was determined with the use of k-means algorithm and three clusters were selected, similarly like regarding the first 3 months of complementary feeding in our previous study (Masztalerz-Kozubek et al., 2022): (1) family, characterized by more frequent meals consumption with family members and with peers; (2) distracted, where toddlers ate more often during watching TV, playtime, or when distracted by parents; (3) separated, characterized by more frequent meals consumption at different times than other family members (Supplementary Table 2).

Dietary patterns were determined using the k-means algorithm, based on the data from FFQ, and three separate clusters were obtained: (1) prohealth, characterized by more frequent intake of fresh fruits, vegetables, natural grain and milk products, fish, legumes, plant oils, unsweetened/unsalted nuts and seeds, water; (2) non-eaters, characterized by one of the less frequent intake of analyzed food items; (3) processed, characterized by more frequent intake of sweetened grain and flavored milk products, red meat, poultry, processed meat, sweetened/salted nuts and seeds, juices, sweets, and salted snacks (Supplementary Table 3). The assessment of the selection of clusters was conducted using ANOVA (analysis of variance) statistics ($p < 0.05$ for all variables).

Factors associated with dietary patterns were investigated using univariate and multivariate adjusted for key covariates (child's age, sex, and socioeconomic and lifestyle status) logistic regression analysis. Separate models included independent variables such as early feeding factors (exclusive breastfeeding duration, complementary foods, and mealtime environment patterns) and current factors (current breastfeeding, mealtime environment pattern, eating behaviors – CEBQ and screen time) and assessed them in relation to three dietary patterns (each pattern as a dependent variable). In the combined model we included factors which were significant in adjusted models for early and current factors. Thus, we did not include some of the subscales from CEBQ (FR, EOE, DD, SE, EUE). In order to meet the criteria for logistic regression, we aggregated some categories when necessary. Results were presented as odds ratio (OR) or adjusted odds ratio (aOR) and confidence intervals (CI) of 95% were calculated. The level of significance of the odds ratio was assessed with a Wald test. Good fit of the models was confirmed by the Hosmer and Lemeshow Goodness-of-Fit Test ($p > 0.05$). Receiver Operating Characteristic (ROC) analysis was used to assess the quality of the classifications, providing a combined description of its specificity and sensitivity. Subsequently, the area under the ROC curve was calculated (AUC). AUC index can be interpreted as the model's ability to accurately classify classes. The value of the AUC index assumes in the range [0,1]. The AUC = 1 means that the model is perfect in classify, while AUC = 0 means that the model incorrectly classify classes (Kleinbaum & Kleim, 2010). AUC index of 0.5 implies that the model is only as good as random choice. Therefore, the minimum AUC should be considered a chance level i.e., AUC = 0.5. In our study AUC for all models ranges from 0.645 to 0.801. Results of logistic regression analyses conducted separately for early and current factors are presented in Supplementary Tables 4–7.

Statistical analysis was conducted in Statistica 13.3 software (TIBCO Software Inc., StatSoft, Cracow, Poland). A p-value of ≤0.05 was considered to indicate statistical significance.

3. Results

Almost 50% of the mothers were 30–34 years, most of them had university education (85.2%) and half of the children were boys (50.1%). Nearly half of the children were exclusively breastfed for 5–7 months, and most of them received first solids between 4 and 6 months (81.4%). Currently, nearly 40% of children were breastfed and almost half of them ate most meals with other family members. No significant differences were found for analyzed variables between girls and boys (Table 1).

3.1. Associations of feeding practices, eating behaviors, and screen time with children's dietary patterns

Results from univariate and adjusted logistic regression for associations between early (exclusive breastfeeding duration, mealtime environment, and complementary foods patterns), current feeding practices (breastfeeding, mealtime environment pattern), eating behaviors (CEBQ), and screen time and dietary patterns are presented in Tables 2 and 3.

In univariate analysis (Table 2), among children who were breastfed for 1–4.9 months, the odds of following a prohealth dietary pattern were decreased by 71% when compared to those who were breastfed for 5–7 months. These odds were also decreased when children in the first 3 months ate separately or during distraction vs with family and followed a commercial complementary foods pattern when compared to homemade pattern. Regarding the last 3 months, children who were not currently breastfed had reduced by half the odds of following a prohealth dietary pattern when compared to those who were currently breastfed. Among children who had screen time, the odds were decreased by 46% and 81% in comparison to children who had no screen time, depending on the exposure. Regarding eating behaviors, children who scored higher in the food fussiness subscale had lower odds of following a prohealth dietary pattern, whereas higher score in the enjoyment of food subscale increased the odds. In the adjusted model commercial complementary foods pattern (aOR 0.42, 95%CI: 0.27–0.67), eating meals during distraction in the last 3 months (aOR 0.42, 95% CI: 0.22–0.83), higher score in food fussiness subscale (aOR 0.70, 95% CI: 0.50–0.99) and screen time higher than 30 min (aOR 0.44, 95% CI: 0.24–0.82) remained significant. The odds of following this

Table 1
Maternal and child characteristics.

Children and maternal characteristics	Total n = 467	Boys n = 234	Girls n = 233	p value
Maternal age, n (%)				
≤29	145 (31)	77 (32.9)	68 (29.2)	0.221[a]
30–34	222 (47.6)	102 (43.6)	120 (51.5)	
≥35	100 (21.4)	55 (23.5)	45 (19.3)	
Maternal education, n (%)				
high school and lower	69 (14.8)	35 (15.0)	34 (14.6)	0.912[a]
University	398 (85.2)	199 (85.0)	199 (85.4)	
Macroeconomic region residence (%GDP EU-27 average), n (%)				
51–100	360 (77.1)	184 (78.6)	176 (75.5)	0.426[a]
101–130	107 (22.9)	50 (21.4)	57 (24.5)	
Child's age (months), n (%)				
12–18	176 (37.7)	93 (39.7)	83 (35.6)	0.310[a]
19–24	120 (25.7)	53 (22.7)	67 (28.8)	
25–36	171 (36.6)	88 (37.6)	83 (35.6)	
EBF duration (months), n (%)				
never/<1	176 (37.7)	92 (39.3)	84 (36.0)	0.624[a]
1–4.9	75 (16.0)	39 (16.7)	36 (15.5)	
5–7	216 (46.3)	103 (44.0)	113 (48.5)	
ABF duration (months), n (%)				
<12	155 (33.2)	82 (35.0)	73 (31.3)	0.677[a]
13–18	160 (34.3)	79 (33.8)	81 (34.8)	
19–36	152 (32.5)	73 (31.2)	79 (33.9)	
Age at CFI (months), n (%)				
<4	54 (11.6)	28 (12.0)	26 (11.2)	0.256[a]
4–6	380 (81.4)	194 (82.9)	186 (79.8)	
≥7	33 (7.0)	12 (5.1)	21 (9.0)	
CF method, n (%)				
BLW	134 (28.7)	62 (26.5)	72 (30.9)	0.401[a]
Mixed	141 (30.2)	69 (29.5)	72 (30.9)	
TSF	192 (41.1)	103 (44.0)	89 (38.2)	
Complementary foods pattern, n (%)				
Homemade	257 (55.0)	125 (53.4)	132 (56.7)	0.482[a]
Commercial	210 (45.0)	109 (46.6)	101 (43.3)	
Mealtime environment pattern - first 3 months, n (%)				
Distracted	55 (11.8)	29 (12.4)	26 (11.1)	0.905[a]
Separated	115 (24.6)	58 (24.8)	57 (24.5)	
Family	297 (63.6)	147 (62.8)	150 (64.4)	
Current breastfeeding, n (%)				
No	293 (62.7)	146 (62.4)	147 (63.1)	0.876[a]
Yes	174 (37.3)	88 (37.6)	86 (36.9)	
Mealtime environment pattern - last 3 months, n (%)				
Family	207 (44.3)	109 (46.6)	98 (42.1)	0.232[a]
Distracted	105 (22.5)	56 (23.9)	49 (21.0)	
Separated	155 (33.2)	69 (29.5)	86 (36.9)	
CEBQ, mean (SD)				
food responsiveness	2.05 (0.7)	2.03 (0.8)	2.07 (0.7)	0.348[b]
emotional over-eating	1.29 (0.5)	1.28 (0.4)	1.31 (0.5)	0.546[b]

(continued on next page)

Table 1 (*continued*)

Children and maternal characteristics	Total	Boys	Girls	*p* value
	n = 467	n = 234	n = 233	
enjoyment of food	3.54 (0.7)	3.56 (0.8)	3.51 (0.7)	0.624[b]
desire to drink	2.74 (0.9)	2.77 (0.9)	2.71 (0.9)	0.356[b]
satiety responsiveness	2.92 (0.6)	2.86 (0.7)	2.97 (0.6)	0.116[b]
slowness in eating	2.69 (0.7)	2.63 (0.7)	2.75 (0.7)	0.072[b]
emotional under-eating	2.59 (1.0)	2.54 (1.0)	2.64 (0.9)	0.178[b]
food fussiness	2.61 (0.9)	2.64 (0.9)	2.58 (0.9)	0.483[b]
Screen time (minutes/day), n (%)				
0	150 (32.1)	70 (29.9)	80 (34.3)	0.660[a]
<30	133 (28.5)	66 (28.2)	67 (28.8)	
30–60	133 (28.5)	72 (30.8)	61 (26.2)	
>60	51 (10.9)	26 (11.1)	25 (10.7)	

EBF – exclusive breastfeeding; ABF – any breastfeeding; CEBQ – Children's Eating Behavior Questionnaire; CFI – complementary feeding introduction; CF – complementary feeding; BLW – baby-led weaning; TSF – traditional spoon-feeding; GDP – gross domestic product.

[a] – chi-square: comparisons between the sexes, for categorical variables; SD – standard deviation.

[b] – U Mann-Whitney test: comparisons between the sexes, for continuous variables.

pattern were higher when children scored higher in the enjoyment of food (aOR 1.52, 95% CI: 1.00–2.30) and satiety responsiveness (aOR 1.80, 95% CI: 1.19–2.73) subscales (Table 3).

In a univariate model (Table 2), the odds of following a non-eaters pattern were higher among children who ate commercial complementary foods more often vs homemade, had distracted or separated mealtime environment patterns in the first and last 3 months when compared to family mealtime environment pattern and scored higher in food fussiness subscale. These odds were lower when children scored higher in the enjoyment of food subscale. In the adjusted model associations persisted when children ate meals during distraction in the first 3 months of complementary feeding, separately in the last 3 months (aOR 2.35, 95% CI: 1.18–4.65; aOR 1.89, 95% CI: 1.12–3.19, respectively) and scored higher in food fussiness subscale (aOR 1.77, 95% CI: 1.24–2.48; Table 3).

Regarding a processed dietary pattern, univariate analysis revealed that children who were exclusively breastfed for 1–4.9 months had higher odds of following this pattern when compared to children who were exclusively breastfed for 5–7 months. Children who in the first 3 months of complementary feeding ate more often commercial complementary foods vs homemade had doubled the odds of following a processed dietary pattern. Among children who followed a distracted mealtime environment pattern, both in the first and last 3 months, these odds were around twice as high compared to children in a family pattern. Lack of current breastfeeding increased the odds of following a processed dietary pattern when compared to group of children who were still breastfed. Also children who scored higher score in food fussiness subscale had these odds increased by around 30%. Screen time substantially increased the odds of following this pattern, by 3–11 times, depending on the exposure, when compared to group of children without screen time exposure. The odds of following a processed dietary pattern were lower when children ate separately in the last 3 months when compared to having meals with the family and scored higher in the enjoyment of food subscale (Table 2). In adjusted model, the following variables remained significant: commercial complementary foods pattern (aOR 2.07, 95% CI: 1.26–3.41), lack of current breastfeeding (aOR 1.96, 95% CI: 1.10–3.50), screen time (<30 min – aOR 2.27, 95% CI: 1.05–4.93; 30–60 min – aOR 4.14, 95% CI: 1.89–9.06; >60 min – aOR 5.46, 95% CI: 2.03–14.69) and enjoyment of food subscale (aOR 0.60, 95% CI: 0.39–0.94; Table 3).

Table 2
Univariate regression analysis models of combined early feeding factors and current feeding, eating behaviors and screen time influencing dietary patterns in children aged 1–3.

Variable	Dietary pattern					
	prohealth (n = 210)		non-eaters (n = 139)		processed (n = 118)	
	OR	95% CI	OR	95% CI	OR	95% CI
EBF duration (months)						
never/<1	0.74	(0.50–1.11)	1.14	(0.73–1.78)	1.31	(0.81–2.09)
1–4.9	0.29	(0.16–0.52)***	1.72	(0.99–2.99)	2.26	(1.28–4.01)**
5-7	ref		ref		ref	
Mealtime environment pattern - first 3 months						
distracted	–		3.19	(1.76–5.77)***	1.96	(1.06–3.62)*
separated	0.34[1]	(0.23–0.51)***	1.97	(1.24–3.14)**	1.27	(0.77–2.08)
family	ref		ref		ref	
Complementary foods pattern						
commercial	0.32	(0.22–0.47)***	1.68	(1.12–2.50)*	2.39	(1.56–3.67)***
homemade	ref		ref		ref	
Current breastfeeding						
yes	ref		ref		ref	
no	0.52	(0.35–0.76)***	0.91	(0.60–1.37)	2.95	(1.80–4.85)***
Mealtime environment pattern - last 3 months						
family	ref		ref		ref	
distracted	0.18	(0.10–0.32)***	2.54	(1.52–4.26)***	2.21	(1.34–3.64)**
separated	0.84	(0.56–1.28)	2.04	(1.27–3.27)**	0.53	(0.31–0.92)*
CEBQ						
enjoyment of food	2.01	(1.54–2.63)***	0.70	(0.53–0.91)**	0.64	(0.48–0.85)**
satiety responsiveness	1.06	(0.79–1.40)	0.96	(0.71–1.31)	0.97	(0.70–1.35)
food fussiness	0.54	(0.43–0.67)***	1.52	(1.21–1.90)***	1.36	(1.07–1.71)*
Screen time (minutes/day)						
0	ref		ref		ref	
<30	0.54	(0.33–0.87)*	1.06	(0.63–1.79)	3.21	(1.56–6.58)***
30-60	0.19[2]	(0.12–0.30)***	1.14	(0.68–1.92)	7.38	(3.72–14.65)***
>60	–		1.72	(0.88–3.34)	11.06	(4.94–24.75)***

EBF – exclusive breastfeeding; CEBQ – Children's Eating Behavior Questionnaire; OR – odds ratio; CI – confidence interval; [1] – analysis conducted on combined categories "distracted" and "separated"; [2] – analysis conducted on combined categories "30–60" and ">60"; *p ≤ 0.05; **p ≤ 0.01; ***p ≤ 0.001.

Table 3
Multivariate logistic regression analysis of combined early and current feeding practices, eating behaviors and screen time influencing dietary patterns in children aged 1–3 (adjusted for child's age, sex, and SLES).

Variable	Dietary pattern					
	prohealth (n = 210)		non-eaters (n = 139)		processed (n = 118)	
	aOR	*95% CI*	aOR	*95% CI*	aOR	*95% CI*
EBF duration (months)						
never/<1	1.17	(0.72–1.92)	0.98	(0.59–1.61)	0.87	(0.50–1.52)
1–4.9	0.52	(0.26–1.07)	1.13	(0.61–2.11)	1.30	(0.66–2.55)
5-7	ref		ref		ref	
Mealtime environment pattern - first 3 months						
distracted	–		2.35	(1.18–4.65)*	0.90	(0.43–1.89)
separated	0.66[1]	(0.40–1.09)	1.53	(0.91–2.57)	0.75	(0.42–1.35)
family	ref		ref		ref	
Complementary foods pattern						
commercial	0.42	(0.27–0.67)***	1.39	(0.88–2.18)	2.07	(1.26–3.41)**
homemade	ref		ref		ref	
Current breastfeeding						
yes	ref		ref		ref	
no	0.89	(0.54–1.47)	0.73	(0.44–1.19)	1.96	(1.10–3.50)*
Mealtime environment pattern - last 3 months						
family	ref		ref		ref	
distracted	0.42	(0.22–0.83)*	1.63	(0.87–3.06)	1.14	(0.60–2.17)
separated	0.67	(0.40–1.12)	1.89	(1.12–3.19)*	0.76	(0.41–1.42)
CEBQ						
enjoyment of food	1.52	(1.00–2.30)*	1.04	(0.69–1.57)	0.60	(0.39–0.94)*
satiety responsiveness	1.80	(1.19–2.73)**	0.68	(0.45–1.01)	0.80	(0.52–1.24)
food fussiness	0.70	(0.50–0.99)*	1.77	(1.26–2.48)***	0.76	(0.52–1.10)
Screen time (minutes/day)						
0	ref		ref		ref	
<30	0.85	(0.49–1.48)	0.85	(0.48–1.53)	2.27	(1.05–4.93)*
30-60	0.44[2]	(0.24–0.82)**	0.79	(0.41–1.52)	4.14	(1.89–9.06)***
>60	–		0.84	(0.35–2.03)	5.46	(2.03–14.69)***

EBF – exclusive breastfeeding; CEBQ – Children's Eating Behavior Questionnaire; aOR – adjusted odds ratio; CI – confidence interval; SLES – socioeconomic and lifestyle status; [1] – analysis conducted on combined categories "distracted" and "separated"; [2] – analysis conducted on combined categories "30–60" and ">60"; *p ≤ 0.05; **p ≤ 0.01; ***p ≤ 0.001.

4. Discussion

Establishing dietary patterns may be affected by many factors that influence the first months of life as well as later on. In univariate analysis we observed that both early feeding practices such as exclusive breastfeeding duration, complementary foods pattern, and mealtime environment pattern, and current factors - breastfeeding, mealtime environment pattern, screen time, and some eating behaviors were related to at least one of the analyzed patterns. However, some of these associations were attenuated in the combined analysis of early and current factors. This may suggest that some factors affect toddler's dietary patterns to a lesser extent, as well as that this influence may be time-dependent.

Many previous studies have suggested positive associations between breastfeeding and diet (Abraham et al., 2012; Barbosa et al., 2022; Grieger et al., 2011; Hamulka et al., 2020; Husk & Keim, 2016; Jones et al., 2015; Kheir et al., 2021; Nicklaus & Remy, 2013; Scott et al., 2012; Vieira et al., 2019). Exclusive breastfeeding was associated with a greater dietary variety for vegetables, meat/fish, and grain/starch foods in toddlerhood and healthy dietary patterns in children aged 6 (Husk & Keim, 2016; Santos et al., 2016). Longer breastfeeding duration was related to a higher frequency of vegetable consumption for breakfast and dinner among children aged 7–12 (Hamulka et al., 2020), lower levels of junk food consumption (Jackson & Johnson, 2017), and higher intake of fruit and vegetables (Kim & Shin, 2022). Additionally, children who were breastfed for a shorter time scored lower in a fish-based dietary pattern (Barbosa et al., 2022) and those who were ever breastfed compared with never breastfed had higher odds of belonging to a positive eating pattern (Abraham et al., 2012). Observed associations between breastfeeding and healthier dietary habits or greater foods acceptance could be explained by the fact that breast milk exposes infants to a variety of flavors (Beauchamp & Mennella, 2009; Robinson & Fall 2012). Breastfeeding was also pointed out as a promising strategy for promoting the consumption of fruits and vegetables among toddlers, especially if mothers eat fruits and vegetables while breastfeeding (Nicklaus, 2016). These observations were partly confirmed in our study, as we noticed that children who were not currently breastfed had almost two-times higher odds of following a processed dietary pattern. In Sitarik et al. (Sitarik et al., 2021) study, breastfeeding was initially associated with a healthier dietary pattern at the age of 10 years. However, after adjustment, this association was no longer significant (confounded by demographic and maternal characteristics). Similarly, in our adjusted model, exclusive breastfeeding duration was no longer related to a prohealth and processed dietary patterns and current breastfeeding to a prohealth dietary pattern. These results suggest that in terms of decreasing the odds of following a processed dietary pattern, longer any breastfeeding duration seems to be more important than exclusive breastfeeding duration, whereas in increasing the odds of following a prohealth dietary pattern other factors may be meaningful. Another possible explanation is that mothers who are breastfeeding longer may follow the guidelines regarding healthy eating more strictly, as in the study of Khalessi and Reich, the authors observed that women who breastfed for more weeks made better nutrition choices for their infants (Khalessi & Reich, 2013).

In our study, children who were fed with commercial complementary foods more often had the odds of following a prohealth dietary pattern reduced by more than half, whereas the odds of following a processed dietary pattern were 2-times higher. This finding is partly similar to Foterek et al. (Foterek et al., 2015) results. They noticed that the proportion of commercial complementary foods in infancy was associated with lower vegetable intake in the same age (but not with fruit and vegetables variety). A possible explanation seems to rather hypothetical in this context. It could be due to a higher dietary variety in homemade vs commercial complementary foods which increased the intake of certain food groups later on. However, another study observed that infants fed with commercial meals had higher vegetable variety than those who received homemade meals (Mesch et al., 2014). Besides, in our study, we investigated the influence on dietary patterns which included many food items, not a single food group. This observation could be also partly explained by the fact that homemade foods are usually characterized by a more complex texture and taste and thus may increase the preference and frequency of intake for products which are considered as more challenging to accept, such as green vegetables, as some of them have a bitter taste (Mennella, 2014). Our results emphasize the importance of giving homemade foods without the addition of salt and sugar, as in homemade complementary foods pattern such meals were served more frequently. Thus, offering well-prepared homemade complementary foods may be a strategy for creating desirable dietary patterns. As complementary feeding pattern remained significant in two out of three patterns (except for a non-eaters pattern), it seems to be one of the most important factors associated with infants' diet. Regarding an association with other early feeding practices and a non-eaters pattern, another factor – distracted mealtime environment pattern in the first months of complementary feeding seems to be more important, as only this association was still observed in a multivariate model. Hence, mealtime practices rather than type of complementary foods may play a role in the development of a non-eaters pattern.

The role of the mealtime environment was also highlighted in relation to the last 3 months of infant's feeding practices. The abovementioned distracted mealtime environment pattern in the first 3 months of complementary feeding increased the odds of following a non-eaters pattern almost 2.5 times. In the last 3 months, eating meals separately increased the odds of following a non-eaters pattern almost two times, whereas eating meals during distraction decreased by more than half the odds of following a prohealth pattern, when compared to eating meals with family. The fact that we observed associations between mealtime practices both in infancy and toddlerhood can be supported by Dallacker et al. findings (Dallacker et al., 2018), who noticed that association between family meals frequency and nutritional health was independent of children's age. A similar trend was observed in Hillesund et al. study (Hillesund et al., 2021), who noticed beneficial associations between family meals and child dietary intake at the age of 12 months. Mou et al. (Mou et al., 2021) also found that less frequent family meals at the age of 4 were associated with lower overall diet quality 4 years later. Additionally, studies conducted among adolescents showed that eating alone was associated with less healthy dietary intake, whereas watching TV even during family meals was related to lower dietary quality (Feldman et al., 2007; Reicks et al., 2019). The positive influence of family meals frequency on dietary outcomes has been also supported in a few reviews that represented a wide age range of study subjects - 2–18 years (Ares et al., 2023; Dallacker et al., 2018; Hammons & Fiese, 2011; Robson et al., 2020; Snuggs & Harvey, 2023; Verhage et al., 2018). Moreover, Haines et al. in their position statement identified eating together as one of the four key themes that encourage and support healthy eating practices among children (Haines et al., 2019). Possible mechanisms underlying these associations might be nutritional and social (Dallacker et al., 2018). Previous studies have shown that family meals can improve diet quality, as they were associated with more nutrient-dense food intake (Verhage et al., 2018). Other explanation arises from parent-child interaction and learning mechanisms during family meals, like modeling eating behaviors or food choices (Dallacker et al., 2018; Mou et al., 2021; Verhage et al., 2018). Our results regarding distracted mealtime environment patterns are especially important as parents usually use distractors (such as watching TV) as an encouraging strategy to consume the meal, whereas presented results have shown the opposite effect of such an approach.

In this study, a higher score in the enjoyment of food subscale increased 1.5 times the odds of following a prohealth dietary pattern and decreased the odds of following a processed pattern by 40%. It may suggest a beneficial role of higher general interest in food in children's nutrition, especially that Haines et al. mentioned the pleasure of eating among key themes that encourage and support healthy eating practices (Haines et al., 2019). Similarly, higher satiety responsiveness also increased the odds of following a prohealth dietary pattern. Food fussiness, in turn, decreased the odds of following this pattern and increased the odds of following a non-eaters patterns. These trends are in line with other authors' findings, who noticed a positive role of higher enjoyment of food on dietary outcomes, such as dietary variety (Vilela et al., 2018) and healthy eating index (da Costa et al., 2022). One of the possible explanation of the enjoyment of food role is that this subscale was also associated with fruit and vegetable liking/intake (Carnell et al., 2016; Fildes et al., 2015). Food fussiness has been previously negatively related to diet variety (Vilela et al., 2018). Additionally, higher ultra-processed food consumption at 4 years was associated with food fussiness at the age of 7 (Vedovato et al., 2021) and 7 year old children with higher diet quality were more likely to have lower food fussiness (also 3 years later; da Costa et al., 2022). Moreover, Sandvik et al. (Sandvik et al., 2022) suggest that decreasing food fussiness may lead to developing healthier dietary patterns. The role of food fussiness subscale may arise from the fact that fussy children more often reject food groups, like vegetables, and thus have lower fruit and vegetable intake/liking (Fildes et al., 2015; Sandvik et al., 2019). Furthermore, it could be also explained by the fact that children in non-eaters pattern are perceived by their parents as more fussy. Observations related to the enjoyment of food and food fussiness are supported by Gregory et al. (Gregory et al., 2010) findings, as they noticed that modeling of healthy eating predicted lower food fussiness and higher interest in food. Results regarding satiety responsiveness are less consistent with other authors' findings. Carnell et al. (Carnell et al., 2016) observed that 4–5 years old children who scored higher in the satiety responsiveness subscale ate less fruits and vegetables. In previous studies, authors observed the same trends for food fussiness as for satiety responsiveness – higher healthy eating index and fruit and vegetable liking were inversely associated with satiety responsiveness (da Costa et al., 2022; Fildes et al., 2015). Additionally, increasing healthy diet variety index (4–7 years) was inversely associated with satiety responsiveness (Vilela et al., 2018). Our previous study highlighted possible associations between early feeding factors and eating behaviors and could partially explain the indirect effect of early feeding practices on dietary patterns through modeling eating behaviors (Masztalerz-Kozubek et al., 2022).

Even though associations between screen time viewing and dietary patterns were attenuated in multivariate analysis, still remained significant, which suggest an important role of this lifestyle component in dietary patterns. Screen time viewing increased the odds of following a processed dietary pattern from 2.3 to 5.5 times, depending on daily exposition, and decreased the odds of following a prohealth pattern by 50%. Our observations confirm previous studies. Lloyd et al. (Lloyd et al., 2014) have found child screen time to be inversely associated with the intake of core foods (nutrient-dense food groups) and in another study, longer screen time increased the odds of unhealthy dietary habits and decreased the odds of healthy dietary habits (Tambalis et al., 2020). Additionally, television viewing negatively influenced the frequency of consumption of fruits, vegetables and green vegetables and increased the frequency of consumption of processed foods, like sweets, pastries, ice cream, and fast food in 9–11 year old children (Borghese et al., 2014). Moreover, two systematic reviews have found the evidence for an association between screen time and adverse dietary outcomes such as less healthy diet quality, higher consumption of unhealthy foods and lower of fruits and vegetables (Shqair et al., 2019; Stiglic & Viner, 2019). Screen time can disturb physiological perceptions of hunger and satiation cues and thus lead to undesirable food choices (Shqair et al., 2019; Tambalis et al., 2020). Our findings are especially worrisome due to the age of the children in the study (1–3 years old), whereas most of the above studies focused on older children. This emphasizes that excessive screen time, except for many adverse effects on children's health and development, also negatively affects children's diet even since toddlerhood and should be limited (WHO, 2019).

4.1. Strengths and limitations

A notable strength of this study is its complexity as we performed the analysis of early and current feeding practices, current eating behaviors, and screen time viewing what enabled us to indicate the most significant factors influencing the diet of children aged 1–3 years. Moreover, some variables such as mealtime environment pattern were assessed in reference to both early and current feeding and thus strengthened the importance of this factor and provided a better understanding of the development of children's dietary patterns. Another strength of the study is the use of dietary patterns as the outcome. As suggested by Mou et al. (Mou et al., 2021), studies should be cautious in the use of single food groups as an index of diet quality. The strengths of our study also include the fact that we made considerable efforts to validate CEBQ in the group of Polish children aged 1–3 years and to ensure equal access to the survey for participants despite differences in backgrounds due to the internet-based character of the study. The value of our work also lies in large sample size.

However, some limitations of our study should be considered. Exposures and outcomes were reported by mothers, so reported bias could occur. Nonetheless, it was minimized by relatively short recall time, which was less than 36 months (Amissah et al., 2017; Li et al., 2005). High sociodemographic status (e.g. education, GDP) of mothers and the potential risk that the questionnaire could only reach mothers with social media exposure and those who were especially interested in their child's nutrition prompted that the generalizability of our results may be limited. Future studies should target a larger cohort. Besides, we could not assess changes in analyzed factors over the time, however, previous studies showed good stability and continuity of parental feeding practices, eating behaviors, or dietary patterns (Eichler et al., 2019; Farrow & Blissett, 2012; Rose et al., 2017). Another limitation lies in the fact that we gathered information only about the frequency of food items consumption, without specifying the amount of consumed products.

5. Conclusions

To our knowledge, this is the first study assessing concurrently early, current feeding practices, eating behaviors, screen time viewing, and dietary patterns. In our study, we demonstrated that factors such as higher enjoyment of food and satiety responsiveness increased the odds of following a prohealth dietary pattern and commercial complementary food pattern (vs homemade), eating meals during distraction, higher food fussiness and screen time decreased these odds. Distracted mealtime environment pattern in the first months of complementary feeding and separated in the last months as well as higher score in the food fussiness subscale increased the odds of following a non-eaters pattern, whereas commercial complementary foods pattern, lack of current breastfeeding, and screen time exposure increased the odds of following a processed dietary pattern.

The present study reinforces the concept that first years of life are important in shaping dietary patterns. Offering homemade complementary foods more often than commercial ones, longer breastfeeding duration, creating a pleasant mealtime environment – without distractors and more frequent family meals, modeling eating behaviors traits such as higher enjoyment of food, satiety responsiveness and lower food fussiness as well as limiting screen time exposure may be helpful in establishing healthy dietary patterns early in life. Toddlerhood in this context seems to be an especially important period. New foods are more likely to be accepted in this time compared with older ages, as after the age of 3–4 years dietary patterns seems to be quite stable (Mennella, 2014). Increasing parents' awareness of the potential long-term impacts of feeding practices and lifestyle may be beneficial in improving children's diets (Bell et al., 2021; Haines et al., 2019; Nicklaus, 2016).

Ethical statement

The study was approved by Ethics Committee of the Faculty of Human Nutrition and Consumer Science, Warsaw University of Life Sciences, Poland (n. 45/2019) and was conducted in compliance with the Declaration of Helsinki. Respondents' consent was waived due to the anonymous nature of the online survey and impossibility of tracking sensitive personal data. No personal or contact information were required.

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Data sharing

Data may be available from the corresponding author upon reasonable request.

CRediT authorship contribution statement

Daria Masztalerz-Kozubek: Conceptualization, Data curation, Formal analysis, Investigation, Validation, Visualization, Writing – original draft. **Monika A. Zielinska-Pukos:** Conceptualization, Investigation, Methodology, Supervision, Writing – review & editing. **Marta Plichta:** Validation, Writing – review & editing. **Jadwiga Hamulka:** Conceptualization, Methodology, Project administration, Resources, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2024.107580.

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The influence of early and current feeding practices, eating behaviors, and screen time on dietary patterns in Polish toddlers - a cross-sectional study

Daria Masztalerz-Kozubek, Monika A. Zielinska-Pukos, Marta Plichta and Jadwiga Hamulka

Supplementary Table 1. Components of the socioeconomic and lifestyle status (SLES).

SLES' single factors	Response categories	Scoring
Place of residence	village	1
	city <50 000 inhabitants	2
	city 50 000 - 100 000 inhabitants	3
	city 100 001 - 500 000 inhabitants	4
	city > 500 001 inhabitants	5
Macroeconomic region residence (%GDP EU-27 average)	<60 %	1
	60-70%	2
	71-80%	3
	>81%	4
Maternal age	<25 years	1
	25-29 years	2
	30-34 years	3
	35-39 years	4
	≥40 years	5
Paternal age	<25 years	1
	25-29 years	2
	30-34 years	3
	35-39 years	4
	≥40 years	5
Maternal educational level	primary	1
	vocational	2
	high school	3
	bachelor degree	4
	master degree	5
Paternal educational level	primary	1
	vocational	2
	high school	3
	bachelor degree	4
	master degree	5
Number of people in the household	2	1
	3	2
	4	3
	5	4
	≥6	5
Economic situation (self-declared)	Money is only enough for the cheapest food	1
	The money is enough for the cheapest food, clothing, and rent, but not enough to cover the loan repayment.	2
	I live frugally, so there's enough money for everything	3
	I have enough money for everything without any special sacrifices, but I don't save for the future	4
	I have enough money for everything and I am also saving for the future	5
Maternal BMI category	obese	1
	overweight	2
	underweight	3
	healthy	4
Smoking status	current -smoker or former-smoker	1
	non-smoker	2

Supplementary Table 2. Component variables in k-means analysis – mealtime environment pattern in the last 3 months.

Frequency of meal consumption in a given way	**Mealtime environment pattern (last 3 months)**			*p* value[1]
	family (n=207)	distracted (n=105)	separated (n=155)	
In the same time than other family members, n (%)				
never or almost never/occasionally	2 (1.0)	6 (5.7)	12 (7.7)	≤0.001
often	28 (13.5)	43 (41.0)	62 (40.0)	
always/almost always	177 (85.5)	56 (53.3)	81 (52.3)	
Separately from other family members, n (%)				
never or almost never	82 (39.6)	11 (10.5)	0 (0.0)	≤0.001
occasionally	118 (57.0)	71 (67.6)	108 (69.7)	
often/always/almost always	7 (3.4)	23 (21.9)	47 (30.3)	
With peers, n (%)				
never or almost never	36 (17.4)	57 (54.3)	139 (89.7)	≤0.001
occasionally	33 (15.9)	21 (20.0)	10 (6.5)	
often	87 (42.0)	21 (20.0)	6 (3.9)	
always/almost always	51 (24.6)	6 (5.7)	0 (0.0)	
During watching TV, n (%)				
never or almost never	146 (70.5)	3 (2.9)	131 (84.5)	≤0.001
occasionally	61 (29.5)	49 (46.7)	24 (15.5)	
often/always/almost always	0 (0.0)	53 (50.5)	0 (0.0)	
When distracted, n (%)				
never or almost never	196 (94.7)	62 (59.0)	141 (91.0)	≤0.001
occasionally	10 (4.8)	31 (29.5)	13 (8.4)	
often	1 (0.5)	12 (11.4)	1 (0.6)	
always/almost always	0 (0.0)	0 (0.0)	0 (0.0)	
During playtime, n (%)				
never or almost never	164 (79.2)	35 (33.3)	124 (80.0)	≤0.001
occasionally	43 (20.8)	51 (48.6)	24 (15.5)	
often	0 (0.0)	19 (18.1)	7 (4.5)	
always/almost always	0 (0.0)	0 (0.0)	0 (0.0)	

[1] – chi-square: comparisons between mealtime environment patterns

Supplementary Table 3. Component variables in k-means analysis – dietary patterns.

Frequency of food items consumption	Dietary pattern			*p* value[1]
	prohealth (n=210)	non-eaters (n=139)	processed (n=118)	
Fresh fruits, n (%)				
never or almost never	1 (0.5)	1 (0.7)	0 (0.0)	
less than once per week	2 (1.0)	5 (3.6)	2 (1.7)	
1 time per week	0 (0.0)	8 (5.8)	2 (1.7)	≤0.001
at least 2–4 times per week	12 (5.7)	28 (20.1)	13 (11.0)	
1 time per day	89 (42.4)	63 (45.3)	70 (59.3)	
several times per day	106 (50.5)	34 (24.5)	31 (26.3)	
Fruit jars/tubes, n (%)				
never or almost never	60 (28.6)	20 (14.4)	15 (12.7)	
less than once per week	62 (29.5)	24 (17.3)	27 (22.9)	
1 time per week	46 (21.9)	30 (21.6)	25 (21.2)	≤0.001
at least 2–4 times per week	37 (17.6)	41 (29.5)	31 (26.3)	
1 time per day	5 (2.4)	22 (15.8)	17 (14.4)	
several times per day	0 (0.0)	2 (1.4)	3 (2.5)	
Green and brassica vegetables (e.g. brussels sprouts, broccoli, cabbage, cauliflower), n (%)				
never or almost never	1 (0.5)	11 (7.9)	5 (4.2)	
less than once per week	14 (6.7)	39 (28.1)	17 (14.4)	
1 time per week	48 (22.9)	44 (31.7)	43 (36.4)	≤0.001
at least 2–4 times per week	98 (46.7)	39 (28.1)	42 (35.6)	
1 time per day	33 (15.7)	5 (3.6)	9 (7.6)	
several times per day	16 (7.6)	1 (0.7)	2 (1.7)	
Yellow-orange vegetables, n (%)				
never or almost never	2 (1.0)	3 (2.2)	0 (0.0)	
less than once per week	2 (1.0)	15 (10.8)	4 (3.4)	
1 time per week	8 (3.8)	25 (18.0)	13 (11.0)	≤0.001
at least 2–4 times per week	101 (48.1)	77 (55.4)	65 (55.1)	
1 time per day	64 (30.5)	17 (12.2)	29 (24.6)	
several times per day	33 (15.7)	2 (1.4)	7 (5.9)	
Other vegetables, n (%)				
never or almost never	0 (0.0)	4 (2.9)	0 (0.0)	
less than once per week	3 (1.4)	11 (7.9)	5 (4.2)	
1 time per week	7 (3.3)	16 (11.5)	14 (11.9)	≤0.001
at least 2–4 times per week	61 (29.0)	63 (45.3)	48 (40.7)	
1 time per day	67 (31.9)	34 (24.5)	36 (30.5)	
several times per day	72 (34.3)	11 (7.9)	15 (12.7)	
Plain grain products, n (%)				
never or almost never	1 (0.5)	0 (0.0)	0 (0.0)	
less than once per week	0 (0.0)	5 (3.6)	0 (0.0)	
1 time per week	4 (1.9)	9 (6.5)	8 (6.8)	≤0.001
at least 2–4 times per week	42 (20.0)	54 (38.8)	48 (40.7)	
1 time per day	110 (52.4)	47 (33.8)	45 (38.1)	
several times per day	53 (25.2)	24 (17.3)	17 (14.4)	

[1] – chi-square: comparisons between dietary patterns

Supplementary Table 3. Component variables in k-means analysis – dietary patterns (cont.).

Frequency of food items consumption	Dietary pattern			p value[1]
	prohealth (n=210)	non-eaters (n=139)	processed (n=118)	
Sweetened grain products, n (%)				
never or almost never	167 (79.5)	87 (62.6)	29 (24.6)	
less than once per week	33 (15.7)	36 (25.9)	35 (29.7)	
1 time per week	6 (2.9)	10 (7.2)	26 (22.0)	≤0.001
at least 2–4 times per week	2 (1.0)	5 (3.6)	22 (18.6)	
1 time per day	1 (0.5)	1 (0.7)	6 (5.1)	
several times per day	1 (0.5)	0 (0.0)	0 (0.0)	
Plain milk and milk products, n (%)				
never or almost never	24 (11.4)	18 (12.9)	3 (2.5)	
less than once per week	9 (4.3)	12 (8.6)	7 (5.9)	
1 time per week	11 (5.2)	16 (11.5)	15 (12.7)	≤0.001
at least 2–4 times per week	45 (21.4)	59 (42.4)	45 (38.1)	
1 time per day	91 (43.3)	30 (21.6)	44 (37.3)	
several times per day	30 (14.3)	4 (2.9)	4 (3.4)	
Flavored milk and milk products, n (%)				
never or almost never	172 (81.9)	79 (56.8)	22 (18.6)	
less than once per week	22 (10.5)	31 (22.3)	22 (18.6)	
1 time per week	6 (2.9)	11 (7.9)	26 (22.0)	≤0.001
at least 2–4 times per week	8 (3.8)	16 (11.5)	26 (22.0)	
1 time per day	2 (1.0)	2 (1.4)	19 (16.1)	
several times per day	0 (0.0)	0 (0.0)	3 (2.5)	
Poultry/rabbit dishes, n (%)				
never or almost never	13 (6.2)	8 (5.8)	0 (0.0)	
less than once per week	11 (5.2)	5 (3.6)	5 (4.2)	
1 time per week	41 (19.5)	41 (29.5)	22 (18.6)	0.004
at least 2–4 times per week	115 (54.8)	78 (56.1)	81 (68.6)	
1 time per day	29 (13.8)	7 (5.0)	8 (6.8)	
several times per day	1 (0.5)	0 (0.0)	2 (1.7)	
Red meat dishes, n (%)				
never or almost never	23 (11.0)	13 (9.4)	3 (2.5)	
less than once per week	49 (23.3)	42 (30.2)	24 (20.3)	
1 time per week	87 (41.4)	54 (38.8)	35 (29.7)	≤0.001
at least 2–4 times per week	44 (21.0)	27 (19.4)	52 (44.1)	
1 time per day	7 (3.3)	3 (2.2)	4 (3.4)	
several times per day	0 (0.0)	0 (0.0)	0 (0.0)	
Processed meat (e.g. ham, sausages), n (%)				
never or almost never	63 (30.0)	19 (13.7)	6 (5.1)	
less than once per week	66 (31.4)	26 (18.7)	17 (14.4)	
1 time per week	41 (19.5)	39 (28.1)	32 (27.1)	≤0.001
at least 2–4 times per week	35 (16.7)	43 (30.9)	52 (44.1)	
1 time per day	5 (2.4)	9 (6.5)	11 (9.3)	
several times per day	0 (0.0)	3 (2.2)	0 (0.0)	

[1] – chi-square: comparisons between dietary patterns

Supplementary Table 3. Component variables in k-means analysis – dietary patterns (cont.).

Frequency of food items consumption	Dietary pattern			*p* value[1]
	prohealth (n=210)	non-eaters (n=139)	processed (n=118)	
Fish, n (%)				
never or almost never	14 (6.7)	17 (12.2)	8 (6.8)	
less than once per week	38 (18.1)	53 (38.1)	29 (24.6)	
1 time per week	111 (52.9)	62 (44.6)	61 (51.7)	≤0.001
at least 2–4 times per week	42 (20.0)	7 (5.0)	19 (16.1)	
1 time per day	4 (1.9)	0 (0.0)	0 (0.0)	
several times per day	1 (0.5)	0 (0.0)	1 (0.8)	
Legumes (including hummus etc.), n (%)				
never or almost never	4 (1.9)	45 (32.4)	20 (16.9)	
less than once per week	53 (25.2)	68 (48.9)	42 (35.6)	
1 time per week	61 (29.0)	19 (13.7)	38 (32.2)	≤0.001
at least 2–4 times per week	66 (31.4)	7 (5.0)	18 (15.3)	
1 time per day	23 (11.0)	0 (0.0)	0 (0.0)	
several times per day	3 (1.4)	0 (0.0)	0 (0.0)	
Plant oils (olive oil, linseed oil, rapeseed oil), n (%)				
never or almost never	0 (0.0)	8 (5.8)	2 (1.7)	
less than once per week	4 (1.9)	30 (21.6)	6 (5.1)	
1 time per week	10 (4.8)	30 (21.6)	28 (23.7)	≤0.001
at least 2–4 times per week	56 (26.7)	46 (33.1)	50 (42.4)	
1 time per day	98 (46.7)	20 (14.4)	26 (22.0)	
several times per day	42 (20.0)	5 (3.6)	6 (5.1)	
Nuts and seeds - unsalted (including flour and butters without salt addition), n (%)				
never or almost never	11 (5.2)	61 (43.9)	25 (21.2)	
less than once per week	11 (5.2)	38 (27.3)	27 (22.9)	
1 time per week	33 (15.7)	28 (20.1)	31 (26.3)	≤0.001
at least 2–4 times per week	74 (35.2)	9 (6.5)	25 (21.2)	
1 time per day	73 (34.8)	3 (2.2)	6 (5.1)	
several times per day	8 (3.8)	0 (0.0)	4 (3.4)	
Nuts and seeds - salted/sweetened (including butters with salt/sugar addition), n (%)				
never or almost never	200 (95.2)	128 (92.1)	93 (78.8)	
less than once per week	5 (2.4)	10 (7.2)	19 (16.1)	
1 time per week	3 (1.4)	1 (0.7)	3 (2.5)	≤0.001
at least 2–4 times per week	0 (0.0)	0 (0.0)	3 (2.5)	
1 time per day	1 (0.5)	0 (0.0)	0 (0.0)	
several times per day	1 (0.5)	0 (0.0)	0 (0.0)	
Water, n (%)				
never or almost never	0 (0.0)	0 (0.0)	3 (2.5)	
less than once per week	0 (0.0)	4 (2.9)	1 (0.8)	
1 time per week	0 (0.0)	1 (0.7)	1 (0.8)	≤0.001
at least 2–4 times per week	0 (0.0)	3 (2.2)	2 (1.7)	
1 time per day	2 (1.0)	2 (1.4)	12 (10.2)	
several times per day	208 (99.0)	129 (92.8)	99 (83.9)	

[1] – chi-square: comparisons between dietary patterns

Supplementary Table 3. Component variables in k-means analysis – dietary patterns (cont.)

Frequency of food items consumption	Dietary pattern			*p* value[1]
	prohealth (n=210)	non-eaters (n=139)	processed (n=118)	
Juices/compote, n (%)				
never or almost never	118 (56.2)	55 (39.6)	2 (1.7)	
less than once per week	52 (24.8)	37 (26.6)	7 (5.9)	
1 time per week	19 (9.0)	15 (10.8)	14 (11.9)	≤0.001
at least 2–4 times per week	12 (5.7)	20 (14.4)	39 (33.1)	
1 time per day	8 (3.8)	9 (6.5)	32 (27.1)	
several times per day	1 (0.5)	3 (2.2)	24 (20.3)	
Sweetened beverages, n (%)				
never or almost never	207 (98.6)	125 (89.9)	77 (65.3)	
less than once per week	2 (1.0)	13 (9.4)	24 (20.3)	
1 time per week	0 (0.0)	1 (0.7)	8 (6.8)	≤0.001
at least 2–4 times per week	1 (0.5)	0 (0.0)	3 (2.5)	
1 time per day	0 (0.0)	0 (0.0)	5 (4.2)	
several times per day	0 (0.0)	0 (0.0)	1 (0.8)	
Boughten sweets, n (%)				
never or almost never	136 (64.8)	67 (48.2)	6 (5.1)	
less than once per week	60 (28.6)	41 (29.5)	29 (24.6)	
1 time per week	9 (4.3)	18 (12.9)	28 (23.7)	≤0.001
at least 2–4 times per week	4 (1.9)	11 (7.9)	39 (33.1)	
1 time per day	1 (0.5)	2 (1.4)	11 (9.3)	
several times per day	0 (0.0)	0 (0.0)	5 (4.2)	
Homemade sweets, n (%)				
never or almost never	21 (10.0)	18 (12.9)	3 (2.5)	
less than once per week	80 (38.1)	66 (47.5)	24 (20.3)	
1 time per week	67 (31.9)	38 (27.3)	46 (39.0)	≤0.001
at least 2–4 times per week	33 (15.7)	15 (10.8)	36 (30.5)	
1 time per day	9 (4.3)	2 (1.4)	7 (5.9)	
several times per day	0 (0.0)	0 (0.0)	2 (1.7)	
Salty snacks (e.g. chips, popcorn), n (%)				
never or almost never	185 (88.1)	109 (78.4)	57 (48.3)	
less than once per week	17 (8.1)	24 (17.3)	33 (28.0)	
1 time per week	8 (3.8)	5 (3.6)	17 (14.4)	≤0.001
at least 2–4 times per week	0 (0.0)	1 (0.7)	8 (6.8)	
1 time per day	0 (0.0)	0 (0.0)	3 (2.5)	
several times per day	0 (0.0)	0 (0.0)	0 (0.0)	

[1] – chi-square: comparisons between dietary patterns

Supplementary Table 4. Univariate logistic regression analysis models of early feeding factors influencing dietary patterns in children aged 1-3.

Variable	Dietary pattern					
	prohealth (n=210)		non-eaters (n=139)		processed (n=118)	
	OR	95% CI	OR	95% CI	OR	95% CI
EBF duration (months)						
never/ <1	0.74	(0.50-1.11)	1.14	(0.73-1.78)	1.31	(0.81-2.09)
1-4.9	0.29	(0.16-0.52)***	1.72	(0.99-2.99)	2.26	(1.28-4.01)**
5-7		ref		ref		ref
Complementary foods pattern						
commercial	0.32	(0.22-0.47)***	1.68	(1.12-2.50)*	2.39	(1.56-3.67)***
homemade		ref		ref		ref
Mealtime environment pattern - first 3 months						
distracted		-	3.19	(1.76-5.77)***	1.96	(1.06-3.62)*
separated	0.34[1]	(0.23-0.51)***	1.97	(1.24-3.14)**	1.27	(0.77-2.08)
family		ref		ref		ref

EBF – exclusive breastfeeding; OR – odds ratio; CI – confidence interval; [1] – analysis conducted on combined categories "distracted" and "separated"; * p≤0.05; ** p≤0.01; *** p≤0.001

Supplementary Table 5. Multivariate logistic regression analysis models of early feeding factors influencing dietary patterns in children aged 1-3 (adjusted for child's age, sex, and SLES).

Variable	Dietary pattern					
	prohealth (n=210)		non-eaters (n=139)		processed (n=118)	
	aOR	95% CI	aOR	95% CI	aOR	95% CI
EBF duration (months)						
never/ <1	1.19	(0.76-1.88)	0.88	(0.55-1.42)	0.97	(0.58-1.62)
1-4.9	0.46	(0.24-0.89)*	1.24	(0.69-2.25)	1.52	(0.81-2.85)
5-7		ref		ref		ref
Complementary foods pattern						
commercial	0.35	(0.23-0.54)***	1.43	(0.93-2.20)	2.54	(1.58-4.08)***
homemade		ref		ref		ref
Mealtime environment pattern - first 3 months						
distracted		-	2.86	(1.55-5.31)***	1.30	(0.67-2.52)
separated	0.44[1]	(0.28-0.69)***	1.80	(1.11-2.90)*	0.94	(0.54-1.61)
family		ref		ref		ref

EBF – exclusive breastfeeding; aOR – adjusted odds ratio; CI – confidence interval; SLES – socioeconomic and lifestyle status; [1] – analysis conducted on combined categories "distracted" and "separated"; * p≤0.05; ** p≤0.01; *** p≤0.001

Supplementary Table 6. Univariate logistic regression analysis models of current feeding, eating behaviors and screen time influencing dietary patterns in children aged 1-3.

Variable	Dietary pattern					
	prohealth (n=210)		non-eaters (n=139)		processed (n=118)	
	OR	95% CI	OR	95% CI	OR	95% CI
Current breastfeeding						
yes		ref		ref		ref
no	0.52	(0.35-0.76)***	0.91	(0.60-1.37)	2.95	(1.80-4.85)***
Mealtime environment pattern - last 3 months						
family		ref		ref		ref
distracted	0.18	(0.10-0.32)***	2.54	(1.52-4.26)***	2.21	(1.34-3.64)**
separated	0.84	(0.56-1.28)	2.04	(1.27-3.27)**	0.53	(0.31-0.92)*
CEBQ						
food responsiveness	1.01	(0.78-1.29)	0.96	(0.73-1.26)	1.04	(0.78-1.38)
emotional over-eating	0.81	(0.54-1.22)	1.04	(0.67-1.60)	1.25	(0.80-1.95)
enjoyment of food	2.01	(1.54-2.63)***	0.70	(0.53-0.91)**	0.64	(0.48-0.85)**
desire to drink	0.87	(0.70-1.07)	0.94	(0.74-1.18)	1.29	(1.01-1.63)*
satiety responsiveness	1.05	(0.79-1.40)	0.96	(0.71-1.31)	0.97	(0.70-1.35)
slowness in eating	1.05	(0.81-1.35)	0.98	(0.75-1.29)	0.96	(0.72-1.29)
emotional under-eating	0.84	(0.70-1.02)	1.08	(0.89-1.33)	1.14	(0.92-1.41)
food fussiness	0.54	(0.43-0.67)***	1.52	(1.21-1.90)***	1.36	(1.07-1.71)*
Screen time (minutes/day)						
0		ref		ref		ref
<30	0.54	(0.33-0.87)*	1.06	(0.63-1.79)	3.21	(1.56-6.58)***
30-60	0.19[1]	(0.12-0.30)***	1.14	(0.68-1.92)	7.38	(3.72-14.65)***
>60		-	1.72	(0.88-3.34)	11.06	(4.94-24.75)***

CEBQ – Children's Eating Behavior Questionnaire; OR – odds ratio; CI – confidence interval; [1] – analysis conducted on combined categories "30-60" and ">60"; * p≤0.05; ** p≤0.01; *** p≤0.001

Supplementary Table 7. Multivariate logistic regression analysis models of current feeding, eating behaviors and screen time influencing dietary patterns in children aged 1-3 (adjusted for child's age, sex, and SLES).

Variable	**Dietary pattern**					
	prohealth (n=210)		non-eaters (n=139)		processed (n=118)	
	aOR	95% CI	aOR	95% CI	aOR	95% CI
Current breastfeeding						
yes		ref		ref		ref
no	0.77	(0.48-1.24)	0.81	(0.50-1.31)	1.97	(1.12-3.46)*
Mealtime environment pattern - last 3 months						
family		ref		ref		ref
distracted	0.30	(0.16-0.58)***	2.29	(1.26-4.16)**	1.24	(0.67-2.27)
separated	0.52	(0.32-0.85)**	2.29	(1.37-3.84)**	0.79	(0.42-1.45)
CEBQ						
food responsiveness	0.83	(0.58-1.20)	1.11	(0.77-1.60)	1.11	(0.73-1.67)
emotional over-eating	0.96	(0.58-1.59)	0.87	(0.52-1.43)	1.22	(0.70-2.13)
enjoyment of food	2.02	(1.29-3.18)**	0.88	(0.57-1.37)	0.52	(0.32-0.85)**
desire to drink	0.94	(0.72-1.23)	0.99	(0.76-1.28)	1.10	(0.83-1.46)
satiety responsiveness	2.16	(1.40-3.34)***	0.63	(0.41-0.97)*	0.70	(0.44-1.14)
slowness in eating	1.22	(0.88-1.69)	0.89	(0.64-1.22)	0.89	(0.63-1.28)
emotional under-eating	0.81	(0.64-1.03)	1.15	(0.91-1.46)	1.12	(0.86-1.46)
food fussiness	0.71	(0.50-0.99)*	1.76	(1.25-2.48)***	0.75	(0.52-1.09)
Screen time (minutes/day):						
0		ref		ref		ref
<30	0.82	(0.48-1.42)	0.88	(0.49-1.58)	2.35	(1.09-5.06)*
30-60	0.43	(0.23-0.78)**	0.84	(0.44-1.60)	4.25	(1.96-9.24)***
>60		-	0.85	(0.35-2.05)	5.29	(1.97-14.20)***

CEBQ – Children's Eating Behavior Questionnaire; aOR – adjusted odds ratio; CI – confidence interval; SLES – socioeconomic and lifestyle status; [1] – analysis conducted on combined categories "30-60" and ">60"; * p≤0.05; ** p≤0.01; *** p≤0.001

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Full Length Article

Sex-specific effects of a Mediterranean diet on lower limb bone strength in Polish children

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Vitamin D

ABSTRACT

Lifestyle factors have the potential to influence bone health in various ways, whether positively or negatively. As osteoporosis is believed to originate in early years, it is therefore essential to indicate factors that may positively affect bone health during childhood. The aim of our study was to investigate the effects of early and current diet, vitamin D supplementation, and BMI z-score on bone properties in a group of children aged 3–7 years. A cross-sectional sample of 205 preschoolers and their parents participated in the study. Dietary assessment was made using a modified version of the Polish-adapted Mediterranean Diet score (MVP-aMED) on the basis of the data from food frequency questionnaire (FFQ), filled out by the parents. Quantitative ultrasound (QUS) was used in the assessment of bone properties. In the sex-stratified analysis, significant associations were observed between MVP-aMED score ($\beta = 0.193$, 95 % CI: 0.005, 0.237; $p = 0.04$), BMI z-score ($\beta = -0.318$, 95 % CI: -1.455, -0.039; $p = 0.04$) and QUS z-score, exclusively among girls. After adjustment, only the relationship with diet remained significant ($\beta = 0.209$, 95 % CI: 0.007, 0.255; $p = 0.04$), suggesting that a higher adherence to the Mediterranean Diet may be associated with better bone properties in girls aged 3–7 years old. Our results emphasize the importance of fostering healthy dietary habits and maintaining proper weight in children in order to promote optimal bone development.

1. Introduction

Osteoporosis is considered to have origins in childhood, despite the fact that predominantly affects individuals as they age [1]. Bone growth during childhood and adolescence may account for approximately half of the bone mass achieved in adulthood [2]. Therefore, it seems highly important to develop optimal peak bone mass during childhood and adolescence to increase the chances for proper bone health and reduce the risk of osteoporosis later in life [1,3]. Several modifiable factors, including breastfeeding, diet, nutritional status, physical activity, and anthropometry are thought to significantly influence bone health [1,4–10].

The association between breastfeeding and bone health outcomes has been extensively investigated across numerous studies [8,11–25]. However, the findings remain inconclusive. While many studies have indicated a positive impact of breastfeeding on offspring bone health [11,18–23], others have not demonstrated such associations [12,13,24–26], or have observed them solely within specific age groups, genders [14], or among preterm infants [15,16]. The ambiguity of these findings is further supported by a systematic review of the literature, which found no consensus regarding the influence of infant feeding method on bone mass at different ages [27], as well as by The National Osteoporosis Foundation's 2016 position statement, which assigned level D, indicating inadequate evidence for infant nutrition [4]. Compared to breastfeeding, the body of research concerning complementary feeding is notably smaller [13,19,28]. A systematic review on complementary feeding and bone health revealed insufficient evidence to draw conclusions regarding the relationship between the timing of introducing complementary products and bone health [28]. Earlier introduction to solids has been associated with higher bone mass [19]. Similar findings were presented by Gridneva et al., where later solid food introduction was linked to lower BMD, although this association was observed only among boys [13].

Since nutrition plays an important role in determining bone health [5,10], several studies aimed to investigate relationships between various food groups, such as dairy [29–32], fruits and vegetables [33,34], as well as dietary patterns or indexes [35–40], and key nutrients like calcium and/or vitamin D [3,31,41–47], with bone parameters.

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Results from reviews suggest that dietary patterns characterized by high intake of fruits and vegetables, whole grains, poultry and fish, and nuts and legumes may positively influence bone health [5,48]. However, there exists ambiguity in studies concerning dairy intake and its impact on bone health. While a generally positive effect has been observed [30,32,49,50], a systematic review concluded that there is "insufficient evidence" to support the effect of dairy on children's bone health, due to scarce evidence from included studies [29]. Certain nutrients, notably vitamin D and calcium, are imperative for optimal bone health and development [4,51], with vitamin D in particular being of paramount importance due to its prevalence in deficiency and its recommended supplementation in children [52]. Nonetheless, it has been hypothesized that an approach focused on assessing dietary patterns rather than individual nutrients may be more appropriate for capturing the effect of diet on bone health [5,36,48,53]. One of the dietary patterns that may be associated with better bone health is the Mediterranean dietary pattern. The impact of the Mediterranean diet on bone health may be influenced by the quantity and quality of certain constituent foods, such as extra virgin olive oil, fruits, vegetables, and fish, owing to their anti-inflammatory and antioxidant properties. These foods could also influence the microbiome, thereby modulating their beneficial effects on bone health [54]. Most studies have focused on older populations, especially peri- and post-menopausal women, suggesting a beneficial role of adherence to the Mediterranean diet on bone health, particularly when optimal calcium intake is met [55–57]. However, results from systematic reviews are inconclusive [58,59]. There is also less data on the link between the Mediterranean diet and bone properties in younger population [58,60,61].

Numerous studies demonstrate the association between nutritional status, as assessed by anthropometric parameters, and bone development in children. Most studies have shown that overweight and/or obese children have a higher bone mineral content (BMC) and bone mineral density (BMD) in comparison to their normal-weight peers [8,9,39,44], which has also been supported by systematic review [7]. On the other hand, Ferrer et al. observed the highest BMC and BMD values among children with normal weight and overweight [2].

The current literature on the impact of various factors on bone health in children is limited. Previous studies have predominantly focused on individual factors, such as breastfeeding [14,17,18,23–25], dietary patterns or food group intake [29,32,33,35–38], or anthropometry [2,9]. Therefore, we conducted an analysis to investigate the effects of early and current diet, vitamin D supplementation, and BMI z-score on bone properties in a group of children aged 3–7.

2. Materials and methods

2.1. Study design and participants

The study was approved by the Ethics Committee of the Faculty of Human Nutrition and Consumer Science, Warsaw University of Life Sciences, Poland (resolution no. 45/2019), and followed the ethical standards recognized by the Declaration of Helsinki.

This cross-sectional study was conducted between October 2021 and June 2023 in two cities in Poland (Kielce, located in the Holy Cross voivodship in the southern Poland, and Warsaw, the capital city situated in the Masovian voivodship in central Poland). Children were recruited from kindergartens through invitation letters and advertisements. Considering the duration of attendance in kindergartens in Poland, the age range of children who participated in the study was 3–7 years. Parents of all participants were provided written information regarding the study's nature, voluntary participation, and the option to withdraw at any stage. Written consent was obtained from each participant's parent or legal guardian prior to enrollment. Inclusion criteria comprised signed informed consent forms, the child's willingness to participate, age between 3 and 7 years, and completion of the questionnaire filled out by the parents. Exclusion criteria included lack of signed informed consent, child's unwillingness to participate, incomplete questionnaire data, age outside the range of 3–7 years, or the presence of any child's diseases. A total of 248 parents provided informed consent. However, 205 participants (82 % of the initial sample) were included in the final analysis due to not meeting age criteria ($n = 2$), incomplete questionnaire data ($n = 33$), absence during measurements in kindergartens ($n = 6$), or unwillingness to participate ($n = 2$) (see Fig. 1).

2.2. Questionnaire

The questionnaire comprised sections about child's feeding in the first year, current nutrition, data regarding anthropometrics, pregnancy and child health, motor development milestones, and sociodemographic data.

2.2.1. Early feeding

Parents provided details regarding breastfeeding practices – whether the child was ever breastfed and for how long. Information about duration of any and exclusive breastfeeding was gathered (in moths). Parents were also asked about formula feeding, the introduction of complementary foods (timing and method), and the types of complementary foods introduced. Using k-means clustering analysis, two distinct patterns of early nutrition were identified. The first pattern was characterized by a shorter duration of both exclusive and any breastfeeding, along with an earlier introduction of solid foods. In contrast, the second pattern exhibited a longer duration of breastfeeding, both exclusive and any, and later introduction of solid foods (Table S1).

2.2.2. Dietary assessment

A 36-item FFQ was administered for the current nutrition assessment. Dietary evaluation was conducted based on a modified version of the Polish-aMED score, as developed by Krusinska et al. [62]. Median frequencies of consumption (times/day) for nine dietary items were considered: vegetables, fresh fruits, grain products, fish, legumes, nuts and seeds, plant oils, milk and milk products, and red and processed meat. A point was assigned if the consumption frequency exceeded the median for the first eight food groups and fell below the median for the last group. The modified version of Polish-aMED score (MVP-aMED score) was ranged from 0 to 9 (Table S2-S3). Changes compared to the original version involved replacing the ratio of vegetables oils to animal fat with the median frequency of consumption of vegetable oils (including olive oil) and adding dairy products due to their role in skeletal development in children.

Parents were also asked about their child's vitamin D supplementation regimen, including its duration. Based on this information, children were categorized into two groups: those receiving vitamin D supplements consistently from birth until the present, and those who do/did not take such supplements or take/took them irregularly.

2.3. Anthropometric measurements

At the visit height and weight measurements were conducted. Body weight was measured to the nearest 0.1 kg using an electronic digital scale (model 899 SECA, Hamburg, Germany), and body height to the nearest 0.1 cm by stadiometer (model 213 SECA, Hamburg, Germany). Subsequently, BMI z-score indicators were calculated based on this data, using the Anthro Survey Analyser [63]. Following the WHO BMI z-score cut-off points [64] the population was categorized into three groups (some aggregated): obese and overweight (BMI z-score > 2.00), at risk of overweight (BMI z-score 1.01–2.00), and normal (−1.6–1).

2.4. Quantitative ultrasound (QUS)

The evaluation of Speed of Sound (SOS) was conducted using the Sunlight Omnisense 9000 (BeamMed, Israel). Measurements were taken

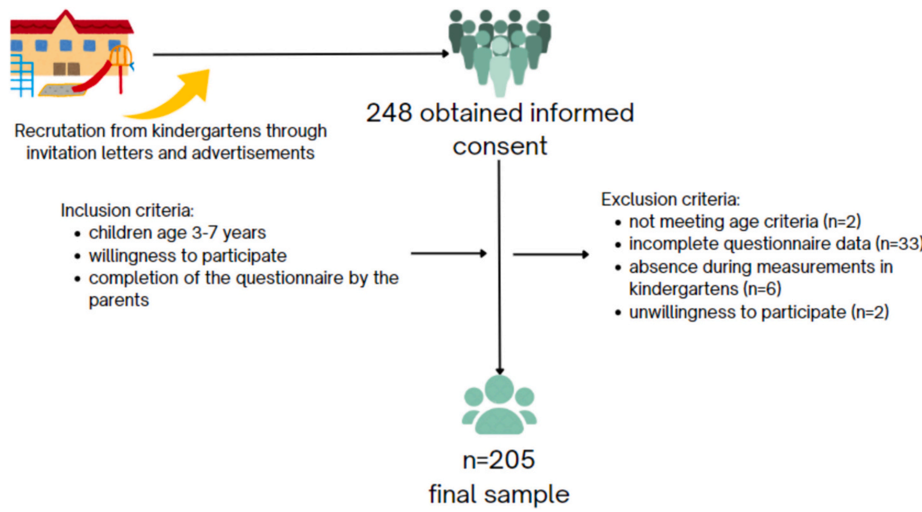

Fig. 1. Flowchart of the study population.

at the midshaft of the nondominant tibia, whether it was left or right. The length of the leg was measured from the plantar surface of the heel to the tip of the knee (knee height). The measurement was conducted using the gauge provided in the skeletal site kit. The exact midpoint of the measured distance was identified, and a line was drawn on the dorso-anterior surface of the leg. At least three repeated measurements were taken, and the software computed the result using the three most consistent measurements. The result is expressed in meters per second (m/s), percentiles, and z-scores matching age and gender, which were used in the analyses. There are no official recommendations for reference values of SOS z-scores. However, a value below −2.0 may indicate a condition of "low bone mineral status," similar to the guidelines suggested for DXA measurements by the International Society for Clinical Densitometry [65]. The quantitative ultrasound technique is safe, easy to use, and devices are portable. Measurements require only a few minutes and are radiation-free, rendering them particularly advantageous for assessing bone mineral status in children. Moreover it provides structural information alongside bone mineral status estimation [65,66].

2.5. Statistical analysis

Statistical analysis was performed using Statistica 13.3 software (TIBCO Software Inc., StatSoft, Cracow, Poland). Nominal variables were represented as percentages, and the Chi squared test was conducted. Following the verification of normality using the Shapiro-Wilk test, differences between quantitative variables were assessed using the Mann-Whitney U or Student's *t*-tests. Qualitative data were presented as percentages (%) and numbers (n), while quantitative data were reported as mean ± standard deviation (SD) or median and interquartile range (IQR). Linear regression was used to explore the relationships of four predictor variables (early feeding pattern, MVP-aMED score, BMI z-score and vitamin D supplementation) with the QUS z-scores as dependent variable. We created univariate and multivariate linear regression models after removing outliers based on Cook's distance. Adjusted model included maternal age as a covariate. Results were presented as β-coefficients (β) along with their 95 % confidence intervals (CI). The R2 parameters and statistical significance levels were calculated and reported. A *p*-value <0.05 was considered statistically significant.

3. Results

Table 1 provides a descriptive analysis of the study population.

Table 1
Characteristics of the study population.

	All (N = 205)	Girls (N = 115)	Boys (N = 90)	p Value
Age (year)	5.0 (4.0–6.0)	5.0 (4.0–6.0)	5.0 (4.0–6.0)	0.50[2]
QUS SOS (m/s)	3932.0 ± 112.40	3590.23 ± 115.38	3648.23 ± 99.97	0.00[3]
QUS (z-score)	−0.13 ± 1.20	−0.32 ± 1.2	0.11 ± 1.17	0.01[3]
BMI (z-score)	0.09 (−0.40–0.75)	0.00 (−0.47–0.67)	0.31 (−0.25–0.88)	0.04[2]
BMI (z-score) categories, n (%)				
Obese/overweight (>2.00)	11 (5.4 %)	5 (4.4 %)	6 (6.7 %)	0.74[1]
ROO (1.01–2.00)	24 (11.7 %)	13 (11.3 %)	11 (12.2 %)	
Normal (−1.6–1.00)	170 (82.9 %)	97 (84.4 %)	73 (81.1 %)	
Early feeding pattern; n (%)				
Shorter BF, earlier CFI	125 (61.0 %)	72 (62.6 %)	53 (58.9 %)	0.59[1]
Longer BF, later CFI	80 (39.0 %)	43 (37.4 %)	37 (41.1 %)	
MVP-aMED score	3.0 (2.0–5.0)	3.0 (2.0–5.0)	3.0 (2.0–5.0)	0.72[2]
Vitamin D supplementation, n (%)				
No/irregularly	50 (24.4 %)	30 (26.1 %)	20 (22.2 %)	0.52[1]
Since birth until now	155 (75.6 %)	85 (73.9 %)	70 (77.8 %)	
Maternal age (years)	36.0 ± 4.96	36.4 ± 4.64	35.5 ± 5.33	0.20[3]

Values are mean ± SD or median (IQR) for continuous variables and number (%) for categorical variables.
QUS – quantitative ultrasound; SOS – speed of sound; BMI – body mass index; ROO – risk of overweight; BF – breastfeeding, CFI – complementary feeding introduction; MVP-aMED – modified version of the 'Polish-adapted Mediterranean Diet'; IQR - interquartile range.
[1] Chi squared test used to determine statistical significance.
[2] Mann-Whitney *U* test to determine statistical significance.
[3] Independent samples *t*-test used to determine statistical significance.

Among the 205 children included in the study, the median age was 5.0 (4.0–6.0) years, and the mean age of the mothers at the time of measurements was 36.0 ± 4.96 years. More than half of the study population followed an early feeding pattern characterized by shorter breastfeeding duration and earlier introduction of complementary feeding (61.0 %). The median value for MVP-aMED score was 3.0 (2.0–5.0) points. The majority of the children had been supplemented with vitamin D since birth until the time of the study (75.6 %) and were categorized as normal weight based on BMI z-scores (82.9 %). The mean values of QUS z-score, SOS and median BMI z-scores were − 0.13 ± 1.20, 3932.0 ± 112.40 and 0.09 (−0.40–0.75), respectively. Statistical significance was observed between girls and boys regarding QUS z-score, SOS and BMI z-score, with boys exhibiting higher values compared to girls (0.11 vs −0.32, p = 0.01; 3648.23 vs 3590.23, p = 0.00 and 0.31 vs 0.00, p = 0.04, respectively).

Linear regression analyses (Table 2–3) were conducted to explore the relationship between QUS z-score and early feeding pattern, current diet, vitamin D supplementation, and BMI z-score. In the univariate model, no associations were found with the analyzed variables (Table 2). However, in the sex-stratified analysis, significant associations were observed between MVP-aMED score, BMI z-score, and QUS z-score, exclusively among girls. Girls with higher MVP-aMED score had higher QUS z-score (β = 0.193, 95 % CI: 0.005, 0.237; p = 0.04). Those who were obese or overweight had lower QUS z-score (β = −0.318, 95 % CI: −1.455, −0.039; p = 0.04; Table 2). After adjustment for maternal age, only the relationship with diet remained significant among girls (β = 0.209, 95 % CI: 0.007, 0.255; p = 0.04; Table 3).

4. Discussion

Our study aimed to investigate the effects of early feeding pattern, current diet, vitamin D supplementation, and BMI z-score on children bone properties, as assessed with QUS. Overall, no significant association was observed between early feeding pattern (breastfeeding, complementary feeding introduction), and vitamin D supplementation with QUS z-score. However, in sex-stratified analysis, a higher adherence to the Mediterranean diet showed a positive association, while BMI z-score showed a negative association with QUS z-score among girls. Nonetheless, in the adjusted model, only the association with diet remained significant.

Breastfeeding has been linked with advantageous effects on bone health [11,18–23]. However, we found no association, which is in line with some previous findings [4,12,13,24,25,27]. To the best of our knowledge, the literature on the associations between timing of introduction of solids and bone outcomes in children is scarce [28]. In two studies, later introduction to solids was negatively related to childhood bone mass and density [13,19]. In the presented study, breastfeeding and time of complementary foods introduction were assessed together as early feeding pattern. The inconsistency between our findings and those of other authors may stem from several possible factors, such as variations in the age at which bone parameters were assessed, measurement methodology, and study design. Most studies have separately analyzed the relationship between breastfeeding and the timing of complementary feeding initiation. Furthermore, breastfeeding might exert a more significant long-term influence, particularly during adolescence, a pivotal stage when approximately 90 % of peak bone mass is attained [27]. In our study, we investigated the impact of breastfeeding on younger children. Significant insights regarding breastfeeding were uncovered by Foley et al., revealing that breastfed children were half as likely to exhibit negative deviations in this parameter and twice as likely to display positive deviations compared to non-breastfed children [22]. The assessments were conducted among older children and adolescents (aged 8 and 16), which may partly account for our failure to demonstrate any association between breastfeeding and bone outcomes.

Our study has found that girls, but not boys, with a higher adherence to the Mediterranean diet, as assessed using a modified version of the Polish-aMED score (MVP-aMED), had higher QUS z-scores. Higher intake of food groups such as vegetables, fruits, grains, fish, legumes, nuts and seeds, plant oils, milk and milk products, and lower intake of red and processed meat, was indicative of a higher MVP-aMED score. The direction of our observations aligns with findings reported by other authors in the field. Wosje et al. demonstrated that a dietary pattern rich in dark-green and deep-yellow vegetables was associated with higher bone mass in children aged 3–8 years [35]. Another study revealed that infant dietary pattern characterized by high intakes of whole grains, eggs, dairy, and cheese was positively associated with bone outcomes at age 6; however, this association was observed only in children who did not receive vitamin D supplementation [40]. Liao et al. reported that children with higher intakes of fruits, milk, and eggs exhibited higher BMC and BMD, whereas a dietary pattern characterized by high intake of refined cereals, preserved vegetables, red meat and animal organs was negatively associated with BMC and BMD in children aged 6–9 years [36]. The importance of a healthy diet was also underscored in studies conducted among older participants. High intake of fruit and vegetables

Table 2
Univariate regression analysis of the predictors of QUS z-score.

Variable	QUS z-score					
	All (N = 200)		Girls (N = 113)		Boys (N = 88)	
	Coefficient (95 % CI)	p value	Coefficient (95 % CI)	p value	Coefficient (95 % CI)	p value
Early feeding pattern						
Shorter BF, earlier CFI	−0.006 (−0.168, 0.154)	0.93	−0.005 (−0.230, 0.218)	0.96	0.037 (−0.193, 0.274)	0.73
Longer BF, later CFI	ref		ref		ref	
R^2	−0.01	0.93	−0.01	0.96	−0.01	0.73
MVP-aMED score	0.061 (−0.046, 0.119)	0.39	0.193 (0.005, 0.237)	0.04	−0.145 (−0.196, 0.037)	0.18
R^2	0.00	0.39	0.03	0.04	0.01	0.18
Vitamin D supplementation						
No/irregularly	−0.066 (−0.271, 0.097)	0.35	−0.112 (−0.394, 0.099)	0.24	0.004 (−0.275, 0.286)	0.97
Since birth until now	ref		ref		ref	
R^2	0.00	0.35	0.00	0.24	−0.01	0.97
BMI z-score						
Obese/overweight (>2.00)	−0.117 (−0.726, 0.229)	0.31	−0.318 (−1.455, −0.039)	0.04	0.061 (−0.523, 0.751)	0.72
ROO (1.01–2.00)	0.027 (−0.344, 0.438)	0.81	0.086 (−0.403, 0.727)	0.57	−0.025 (−0.574, 0.496)	0.89
Normal (−1.6–1.00)	ref		ref		ref	
R^2	0.00	0.39	0.05	0.03	−0.02	0.92

BF – breastfeeding; CFI – complementary feeding introduction; MVP-aMED – modified version of the 'Polish-adapted Mediterranean Diet'; BMI – Body Mass Index; ROO – risk of overweight.

Table 3
Multivariate regression analysis of the predictors of QUS z-score.

Variable	QUS z-score					
	All ($N = 200$)		Girls ($N = 113$)		Boys ($N = 88$)	
	Coefficient (95 % CI)	*p* value	Coefficient (95 % CI)	*p* value	Coefficient (95 % CI)	*p* value
Early feeding pattern						
Shorter BF, earlier CFI	0.024 (−0.147, 0.203)	0.75	0.138 (−0.082, 0.410)	0.19	−0.05 (−0.254, 0.243)	0.97
Longer BF, later CFI	ref		ref		ref	
MVP-aMED score	0.040 (−0.067, 0.114)	0.60	0.209 (0.007, 0.255)	0.04	−0.183 (−0.232, 0.032)	0.14
Vitamin D supplementation						
No/irregularly	−0.064 (−0.274, 0.107)	0.39	−0.097 (−0.370, 0.115)	0.30	−0.071 (−0.401, 0.215)	0.55
Since birth until now	ref		ref		ref	
BMI z-score						
Obese/overweight (>2.00)	−0.110 (−0.716, 0.250)	0.34	−0.288 (−1.387, 0.033)	0.06	0.018 (−0.616, 0.684)	0.92
ROO (1.01–2.00)	0.020 (−0.362, 0.432)	0.86	0.058 (−0.460, 0.677)	0.71	−0.021 (−0.578, 0.511)	0.90
Normal (−1.6–1.00)	ref		ref		ref	
Maternal age	−0.031 (−0.040, 0.026)	0.68	0.066 (−0.031, 0.064)	0.50	−0.118 (−0.070, 0.022)	0.31
R^2	−0.01	0.77	0.06*	0.04	−0.04	0.81

BF – breastfeeding; CFI – complementary feeding introduction; MVP-aMED – modified version of the 'Polish-adapted Mediterranean Diet'; BMI – Body Mass Index; ROO – risk of overweight.

was positively associated with bone area and density in early pubertal girls [33,34]. Kindler et al. reported a positive association between Healthy Eating Index and bone density in youths aged 10–23 years [39]. Among adolescents, those with the highest intakes in the milk and cereal dietary pattern had lower chances of having low bone density [37], a finding supported by another study where male participants aged 10–25 years in the highest tertile of the milk-cereal and whole-grain pattern were less likely to have low bone density [38]. Dietary patterns during adolescence may also have long-term impacts on bone health. Higher intake of milk and alternatives, as well as fruits and vegetables in adolescence was positively associated with bone structure in adult females [67]. Additionally, adolescents with a dietary pattern rich in dark green vegetables, eggs, non-refined grains, and legumes (a "Vegetarian-style") had higher adult BMC and BMD [68]. This is particularly noteworthy as the "Vegetarian-style" dietary pattern showed the strongest tracking over time, suggesting that healthy dietary habits established in childhood and adolescence may persist into adulthood [69]. The significance of a healthy diet for bone health is further supported by reviews [5,48,53]. Nonetheless, some authors did not find associations between diet and bone outcomes [26,60,61,70]. A few studies also observed sex-specific associations. In studies by McGartland [33] and Movassagh [67], effects were observed only in girls, similar to our findings. We hypothesize that our observations being exclusive to girls may be attributed to the fact that boys exhibited better bone outcomes and that girls (and older women) are already at increased risk of osteoporosis [1,33]. Possible mechanisms that could explain the positive effects of an overall healthier diet on bone health stem from the characteristics of Mediterranean diet. A high intake of fruits, vegetables, grains, legumes, nuts, fish, and plant oils may contribute to the bone-sparing effect of the Mediterranean diet as these foods have alkalinising properties [71]. Additionally, antioxidants (such as vitamin C, carotenoids), potassium, magnesium, vitamin K, and dietary fiber, have been correlated with positive impacts on musculoskeletal health and are important in reducing risk of osteoporosis and fractures [55]. Polyphenols (plentiful in fruits, vegetables, and olive oil) and omega-3 fatty acids (in fish) possess anti-inflammatory properties that are also important for bone health and have demonstrated protective effects against bone loss [55,56,72]. The mechanisms of action for antioxidants (including polyphenols and carotenoids) in bone remodeling involve the suppression of osteoclast activity and the enhancement of osteoblast differentiation [55]. The interactive and synergistic effects of dietary components within the Mediterranean diet likely have a more substantial combined impact, even though each individual component plays a crucial role in musculoskeletal health [55]. In our modified version of the Polish-aMED score, we also included dairy in the diet scoring due to its significant properties in terms of bone development. As a source of calcium, phosphorus, and protein, dairy products appear to be vital for bone health [30,32,49,50,73].

This study did not demonstrate an association between vitamin D supplementation and QUS z-score. No differences were observed between children who did not supplement with vitamin D or supplemented irregularly and those who had been supplemented with this vitamin since birth. Interventional studies, which were conducted among infants and adolescents did not show the effect of vitamin D supplementation on bone parameters [45–47]. Similarly, observational studies also have not found an association between vitamin D supplementation [26,43], intake [3,44], or status [74,75] and bone parameters in groups of children aged 5–18 years. On the contrary, Savino et al. [76] observed higher values of bone parameters in QUS measurements in infants who received vitamin D supplementation, whereas Alghadir et al. [41] found that children with lowest vitamin D values exhibited lower BMD and BMC. Nonetheless, the role of vitamin D in proper skeletal development is significant. Moreover, considering its numerous extraskeletal benefits, supplementation should be considered in accordance with guidelines for specific populations [4,52,77].

Univariate analysis revealed that girls with obesity and overweight had a lower QUS z-score compared to those with normal body weight. Two prior studies have reported similar findings. Eliakim et al. observed a reduction in bone strength, as measured by QUS, in obese children aged 6–17 years [78]. Furthermore, Wang et al. observed that a higher BMI was associated with low/reduced BMD among adolescents [79]. However, our observation was not sustained in the adjusted model. Generally, the majority of recent studies have reported a positive association between overweight/obesity and bone outcomes [8,9,39,44,80]. Additionally, a systematic review and meta-analysis has shown that children with overweight and obesity have greater bone mineral density in comparison to normal-weight children [7]. Mechanism seems to be mainly mechanical and explained by greater lean mass in children with overweight or obesity [6,9]. On the other hand, excess adiposity has negative effect on bone indicators through cellular mechanisms. For example, higher leptin levels were associated with lower BMC in children with overweight and obesity [81]. In addition, these children appear to have more injuries and fractures than normal-weight children [82]. Moreover, the long-term effects of childhood overweight and obesity on bone health in adulthood remain uncertain [7].

Our study has several possible implications, and its results should be interpreted in the context of skeletal development during childhood. Bone development depends on the processes of modeling and remodeling, with modeling occurring exclusively in growing children. This process involves regulated uncoupling of osteoblast-driven bone formation and osteoclast-driven bone resorption, resulting in an increase in bone mass and significant and dynamic alterations in bone size and shape [48,83]. The development of healthy bones during childhood lays the foundation for optimal skeletal health in adulthood [48]. The bone mass accumulated in this period is arguably the most critical determinant of skeletal health and the risk of osteoporosis later in life [83]. Bone status during childhood strongly predicts bone status in young adulthood and lifestyle factors have the potential to influence bone health in various ways, whether positively or negatively [4,84]. In addition, healthy eating habits established in childhood may persist into adulthood, as evidenced by the strong tracking of a "Vegetarian-style" dietary pattern [69]. This emphasizes the potential benefits of assessing bone mass in children for identifying individuals at risk for osteoporosis later in life.

4.1. Strengths and limitations of the study

There are several strengths of this study. Firstly, the large number of participants drawn from two localizations. Secondly, our analysis incorporates the use of a dietary index as a variable. An increasing body of evidence indicates that this approach may provide more comprehensive insights into the effects of diet on bone health, given that people do not consume single nutrients [5,10,36,48]. Furthermore, dietary patterns appear to be relatively stable measurements when compared to the day-to-day variation in the intake of certain nutrients [10]. Thirdly, we used BMI z-scores to classify the children based on their weight status, whereas some prior studies solely used height or total BMI. Given that the relationship between weight and height changes with age and sex in children during the first two decades of life, this method appears to be more precise [2].

The use of QUS method in our study can be perceived both as a strength and a limitation of the research. Among the advantages of this method, one should include its non-invasive nature, device portability, lack of radiation, and ease of measurement in children [65]. Moreover, QUS evaluates bone both quantitatively and qualitatively, examining factors such as connectivity, elasticity, and architecture, in addition to mineral density. This comprehensive assessment offers a measure of "bone quality", used as an overall indicator of bone strength [66].

However, we have to address some limitations, as dual-energy X-ray absorptiometry (DXA) is currently regarded as the reference standard for assessing bone mineral content and density and the clinical usefulness of QUS has not yet been investigated. Inconsistent findings among DXA and QUS measurements do not imperatively indicate methodological error, because these methods do not evaluate the same properties of bone tissue. Thus, they are not interchangeable in evaluating bone status in children [66,85]. Nonetheless, QUS measurements could be a feasible initial screening method for evaluating bone mineral status in children [65]. Another limitation arises from the fact that the majority of the studies we discussed utilized DXA to assess bone outcomes. However, we focused on the direction of the observations. Nevertheless, our findings should be interpreted with caution. Natland et al. [86] found that even twenty years after mothers gave birth, the duration of breastfeeding was recalled with considerable accuracy, thereby minimizing the risk of memory bias, as information regarding breastfeeding duration and the introduction of complementary feeding in our study was reported by the mothers themselves.

5. Conclusions

In conclusion, the findings of our study suggest that a higher adherence to the Mediterranean diet may be associated with better bone properties in girls aged 3–7 years old. Although the relationship between BMI and bone outcome was observed only in the univariate model.

Taking together, our results emphasize the importance of fostering healthy dietary habits and maintaining proper weight in children in order to ensure proper bone development, as osteoporosis is thought to have origins in childhood [1].

However, to substantiate these findings, future research are needed, especially studies with longitudinal designs, utilizing quantitative ultrasound method to assess their usefulness and clinical validity in larger populations.

Ethical statement

The study was approved by Ethics Committee of the Faculty of Human Nutrition and Consumer Science, Warsaw University of Life Sciences, Poland (n. 45/2019) and was conducted in compliance with the Declaration of Helsinki. No personal or contact information were required.

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CRediT authorship contribution statement

Daria Masztalerz-Kozubek: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Monika A. Zielinska-Pukos:** Writing – review & editing, Methodology, Formal analysis, Conceptualization. **Jadwiga Hamulka:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bone.2024.117252.

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Sex-specific effects of a Mediterranean diet on lower limb bone strength in Polish children

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Table S1. Component variables in k-means analysis – early feeding pattern.

Variable	Early feeding pattern: shorter BF, earlier CFI (N = 125)	Early feeding pattern: longer BF, later CFI (N = 80)	p value
EBF duration; n (%)			
never/<4 months	109 (87.2)	11 (13.8)	0.00[1]
≥ 4 months	16 (12.8)	69 (86.2)	
ABF duration; n (%)			
≤ 12 months	97 (77.6)	10 (12.5)	0.00[1]
≥ 12 months	28 (22.4)	70 (87.5)	
Age of CFI; n (%)			
<6 months	116 (92.8)	22 (27.5)	0.00[1]
≥ 6 months	9 (7.2)	58 (72.5)	

BF – breastfeeding; EBF – exclusive breastfeeding; ABF – any breastfeeding; CFI – complementary feeding introduction; [1] Chi squared test used to determine statistical significance

Table S2. Description of food groups for the calculation of the modified version of the 'Polish-adapted Mediterranean Diet' score (0–9 points).

Food group/dietary items	Criteria for 1 point
Vegetables: green and brassica vegetables (e.g. brussels sprouts, broccoli, cabbage, cauliflower), yellow-orange vegetables (e.g. carrot, pepper), other vegetables, vegetable preserves	Greater than median intake (times/day)
Fresh fruits	Greater than median intake (times/day)
Grain products: plain and sweetened, e.g. groats, oat flakes, millet flakes, rice, pasta, cereals	Greater than median intake (times/day)
Fish: fresh, frozen, smoked or canned	Greater than median intake (times/day)
Legumes, e.g. lentils, beans, chickpeas, legumes in dishes (hummus etc.)	Greater than median intake (times/day)
Nuts and seeds: unsalted and salted	Greater than median intake (times/day)
Plant oils: e.g. olive oil, rapeseed oil, linen oil	Greater than median intake (times/day)
Milk and milk products: e.g. milk, yoghurts, cottage cheese, hard cheese, mozzarella, feta cheese	Greater than median intake (times/day)
Red and processed meat	Lower than median intake (times/day)

Table S3. Reference medians of food frequency consumption for calculating the modified version of the 'Polish-adapted Mediterranean Diet' score (0–9).

Frequency of consumption of food groups (times/day)[1]	Median[2]	Interquartile range
Vegetables	1.287	0.60-2.00
Fruits	1.000	0.43-1.00
Grains	1.000	0.57-1.43
Fish	0.143	0.03-0.17
Legumes	0.000	0.00-0.03
Nuts and seeds	0.050	0.03-0.29
Plant oils	0.429	0.14-0.43
Milk and milk products	1.287	0.88-2.03
Red and processed meat	0.454	0.17-0.57

[1] - food frequency consumption was expressed as a times/day after assigning the values for categories of frequencies as follows: *never or almost never* - 0, *less than once a week* - 0.025, *once a week* - 0.143, *at least 2–4 times a week* - 0.429, *once a day* - 1, *several times a day* - 2; [2] - reference median of food frequency consumption

9. Oświadczenia współautorów

Warszawa, 05.12.2025 r.

prof. dr hab. Jadwiga Hamułka

OŚWIADCZENIE

Jako współautor pracy pt. **„Early Feeding Factors and Eating Behaviors among Children Aged 1–3: A Cross-Sectional Study"** oświadczam, iż mój własny wkład merytoryczny w przygotowanie, przeprowadzenie i opracowanie badań oraz przedstawienie pracy w formie publikacji stanowi:
współtworzenie koncepcji i metodyki badania, współudział w korektach oraz krytyczną weryfikację manuskryptu i nadzór merytoryczny.
Mój udział procentowy w przygotowaniu publikacji określam jako 25%.
Wkład Darii Masztalerz-Kozubek w powstawanie publikacji określam jako 55%.
Obejmował on:
współtworzenie koncepcji i metodyki badania, zebranie i przechowywanie danych, przeprowadzenie analizy statystycznej danych, wizualizację danych, przygotowanie oryginalnej wersji manuskryptu oraz współudział w korektach.

Jednocześnie wyrażam zgodę na wykorzystanie w/w pracy jako część rozprawy doktorskiej mgr Darii Masztalerz-Kozubek.

....
(podpis oświadczającego)

Warszawa, 05.12.2025 r.

dr inż. Monika Zielińska-Pukos

OŚWIADCZENIE

Jako współautor pracy pt. **„Early Feeding Factors and Eating Behaviors among Children Aged 1–3: A Cross-Sectional Study"** oświadczam, iż mój własny wkład merytoryczny w przygotowanie, przeprowadzenie i opracowanie badań oraz przedstawienie pracy w formie publikacji stanowi:

współtworzeniu koncepcji i metodyki badania, współudziale w analizie statystycznej danych, współudziale w korektach, pełnienie roli autora korespondencyjnego.

Mój udział procentowy w przygotowaniu publikacji określam jako 20%.

Wkład Darii Masztalerz-Kozubek w powstawanie publikacji określam jako 55%.

Obejmował on:

współtworzenie koncepcji i metodyki badania, zebranie i przechowywanie danych, przeprowadzenie analizy statystycznej danych, wizualizację danych, przygotowanie oryginalnej wersji manuskryptu oraz współudział w korektach.

Jednocześnie wyrażam zgodę na wykorzystanie w/w pracy jako część rozprawy doktorskiej mgr Darii Masztalerz-Kozubek.

Monika Zielińska-Pukos

....

(podpis oświadczającego)

Warszawa, 05.12.2025 r.

prof. dr hab. Jadwiga Hamułka

OŚWIADCZENIE

Jako współautor pracy pt. **„The influence of early and current feeding practices, eating behaviors, and screen time on dietary patterns in Polish toddlers - a cross-sectional study"** oświadczam, iż mój własny wkład merytoryczny w przygotowanie, przeprowadzenie i opracowanie badań oraz przedstawienie pracy w formie publikacji stanowi:

współtworzenie koncepcji i metodyki badania, współudział w korektach oraz krytyczną weryfikację manuskryptu, nadzór merytoryczny, pełnienie roli autora korespondencyjnego..

Mój udział procentowy w przygotowaniu publikacji określam jako 25%.

Wkład Darii Masztalerz-Kozubek w powstawanie publikacji określam jako 52%.

Obejmował on:

współtworzenie koncepcji i metodyki badania, zebranie i przechowywanie danych, współudział w analizie statystycznej danych i walidacji, wizualizację danych, przygotowanie oryginalnej wersji manuskryptu oraz współudział w korektach.

Jednocześnie wyrażam zgodę na wykorzystanie w/w pracy jako część rozprawy doktorskiej mgr Darii Masztalerz-Kozubek.

....

(podpis oświadczającego)

Warszawa, 05.12.2025 r.

dr inż. Monika Zielińska-Pukos

OŚWIADCZENIE

Jako współautor pracy pt. **„The influence of early and current feeding practices, eating behaviors, and screen time on dietary patterns in Polish toddlers - a cross-sectional study"** oświadczam, iż mój własny wkład merytoryczny w przygotowanie, przeprowadzenie i opracowanie badań oraz przedstawienie pracy w formie publikacji stanowi:

współtworzeniu koncepcji i metodyki badania, współudziale w analizie statystycznej danych, współudziale w korektach i nadzorze merytorycznym.

Mój udział procentowy w przygotowaniu publikacji określam jako 18%.

Wkład Darii Masztalerz-Kozubek w powstawanie publikacji określam jako 52%.

Obejmował on:

współtworzenie koncepcji i metodyki badania, zebranie i przechowywanie danych, współudział w analizie statystycznej danych i walidacji, wizualizację danych, przygotowanie oryginalnej wersji manuskryptu oraz współudział w korektach.

Jednocześnie wyrażam zgodę na wykorzystanie w/w pracy jako część rozprawy doktorskiej mgr Darii Masztalerz-Kozubek.

Monika Zielińska-Pukos

....

(podpis oświadczającego)

Warszawa, 05.12.2025 r.

dr inż. Marta Plichta

OŚWIADCZENIE

Jako współautor pracy pt. **„The influence of early and current feeding practices, eating behaviors, and screen time on dietary patterns in Polish toddlers - a cross-sectional study"** oświadczam, iż mój własny wkład merytoryczny w przygotowanie, przeprowadzenie i opracowanie badań oraz przedstawienie pracy w formie publikacji stanowi:

walidację kwestionariusza, współudział w przygotowaniu oryginalnej wersji manuskryptu i współudział w korektach.

Mój udział procentowy w przygotowaniu publikacji określam jako 5%.

Wkład Darii Masztalerz-Kozubek w powstawanie publikacji określam jako 52%.

Obejmował on:

współtworzenie koncepcji i metodyki badania, zebranie i przechowywanie danych, współudział w analizie statystycznej danych i walidacji, wizualizację danych, przygotowanie oryginalnej wersji manuskryptu oraz współudział w korektach.

Jednocześnie wyrażam zgodę na wykorzystanie w/w pracy jako część rozprawy doktorskiej mgr Darii Masztalerz-Kozubek.

Plichta Marta

....

(podpis oświadczającego)

Warszawa, 05.12.2025 r.

prof. dr hab. Jadwiga Hamułka

OŚWIADCZENIE

Jako współautor pracy pt. **„Sex-specific effects of a Mediterranean diet on lower limb bone strength in Polish children"** oświadczam, iż mój własny wkład merytoryczny w przygotowanie, przeprowadzenie i opracowanie badań oraz przedstawienie pracy w formie publikacji stanowi:

współtworzenie koncepcji i metodyki badania, współudział w korektach oraz krytyczną weryfikację manuskryptu i nadzór merytoryczny, pełnienie roli autora korespondencyjnego.

Mój udział procentowy w przygotowaniu publikacji określam jako 25%.

Wkład Darii Masztalerz-Kozubek w powstawanie publikacji określam jako 55%.

Obejmował on:

współtworzenie koncepcji i metodyki badania, przeprowadzenie pomiarów, zebranie i przechowywanie danych, przeprowadzenie analizy statystycznej danych, wizualizację danych, przygotowanie oryginalnej wersji manuskryptu oraz współudział w korektach.

Jednocześnie wyrażam zgodę na wykorzystanie w/w pracy jako część rozprawy doktorskiej mgr Darii Masztalerz-Kozubek.

Hamułka

....

(podpis oświadczającego)

Warszawa, 05.12.2025 r.

dr inż. Monika Zielińska-Pukos

OŚWIADCZENIE

Jako współautor pracy pt. **„Sex-specific effects of a Mediterranean diet on lower limb bone strength in Polish children"** oświadczam, iż mój własny wkład merytoryczny w przygotowanie, przeprowadzenie i opracowanie badań oraz przedstawienie pracy w formie publikacji stanowi:

współtworzeniu koncepcji i metodyki badania, współudziale w analizie statystycznej danych, współudziale w korektach i nadzorze merytorycznym.

Mój udział procentowy w przygotowaniu publikacji określam jako 20%.

Wkład Darii Masztalerz-Kozubek w powstawanie publikacji określam jako 55%.

Obejmował on:

współtworzenie koncepcji i metodyki badania, przeprowadzenie pomiarów, zebranie i przechowywanie danych, przeprowadzenie analizy statystycznej danych, wizualizację danych, przygotowanie oryginalnej wersji manuskryptu oraz współudział w korektach.

Jednocześnie wyrażam zgodę na wykorzystanie w/w pracy jako część rozprawy doktorskiej mgr Darii Masztalerz-Kozubek.

Monika Zielińska-Pukos

(podpis oświadczającego)

10. Opinia Komisji Bioetycznej

Załącznik Nr 4 do Regulaminu
Komisji Etyki Badań Naukowych z Udziałem Ludzi działającej przy Wydziale Nauk o Żywieniu Człowieka i Konsumpcji SGGW

Szkoła Główna Gospodarstwa Wiejskiego
w Warszawie
Wydział Nauk o Żywieniu Człowieka i Konsumpcji
KOMISJA ETYKI BADAŃ NAUKOWYCH Z UDZIAŁEM LUDZI
02-776 Warszawa, ul. Nowoursynowska 159 C
tel. (48) 22 59-37030

UCHWAŁA KOMISJI ETYKI BADAŃ NAUKOWYCH z UDZIAŁEM LUDZI

przy Wydziale Nauk o Żywieniu Człowieka i Konsumpcji SGGW

w sprawie zgodności projektu badania z zasadami etyki

z dnia 19.07.2019 r.

Nr Uchwały 45p/2019

TYTUŁ BADANIA

Związek między czynnikami żywieniowymi, środowiskowymi i socjodemograficznymi, a rozwojem dzieci we wczesnym okresie życia

DANE WNIOSKODAWCY

Imię i nazwisko Wnioskodawcy projektu **dr hab. Jadwiga Hamułka, prof. SGGW**
Imię i nazwisko wykonawcy (-ów) **dr hab. Jadwiga Hamułka, prof. SGGW, Daria Masztalerz-Kozubek, mgr inż. Monika Zielińska, pracownicy, doktoranci i studenci Katedry Żywienia Człowieka**
Miejsce prowadzenia badań **Zakład Oceny Żywienia, Katedra Żywienia Człowieka, Wydział Nauk o Żywieniu Człowieka i Konsumpcji, Szkoła Główna Gospodarstwa Wiejskiego w Warszawie**
Czas prowadzenia badań **Od daty wydania uchwały pozytywnej KEBNzUL do 31 grudnia 2024 r.**

Po zapoznaniu się z przedstawioną dokumentacją dotyczącą projektu badawczego o w/w tytule, Komisja Etyki Badań Naukowych z Udziałem Ludzi przy Wydziale Nauk o Żywieniu Człowieka i Konsumpcji SGGW działając na podstawie § 12, § 14 i § 16 Regulaminu Komisji Etyki Badań Naukowych z Udziałem Ludzi działającej przy Wydziale Nauk o Żywieniu Człowieka i Konsumpcji postanawia w przedmiocie zgodności projektu z zasadami etycznymi wydać opinię:

Pozytywną **Warunkowo pozytywną** **Negatywną**

UZASADNIENIE

Wniosek spełnia wymagania formalne i nie narusza zasad etyki w zakresie badań z udziałem ludzi.

PRZEWODNICZĄCA
Komisji Etyki Badań Naukowych
z Udziałem Ludzi
Prof. dr hab. Joanna Gromadzka-Ostrowska

Warszawa, 19.07.2019 r.

....
Podpis Przewodniczącego Komisji

Załącznik Nr 4 do Regulaminu
Komisji Etyki Badań Naukowych z Udziałem Ludzi działającej przy Wydziale Nauk o Żywieniu Człowieka i Konsumpcji SGGW

Potwierdzam odebranie Uchwały nr 45p/2019 z dnia 19.07.2019 r.

Warszawa, dnia …………………… ……………………………………………………
Czytelny Podpis Wnioskodawcy