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Precision Nutrition and Artificial Intelligence Mobile Apps: A Narrative Review †

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Abstract: This literature overview describes the potential benefits associated with the integration of precision nutrition and artificial intelligence (AI). PubMed was searched up until June 2023 to identify clinical studies that focused on AI dietary apps used in precision nutrition. The search yielded a total of 198 results, out of which 7 clinical studies were deemed relevant and included in this analysis. These studies examined some applications of AI mobile apps in various areas, including regulating nutrient intake, aiding in weight loss, enhancing dietary treatments for chronic diseases, and predicting metabolic parameters such as glucose levels in individuals with diabetes. Despite some limitations, the findings indicated that these apps demonstrated a satisfactory level of accuracy in accomplishing their intended tasks. The advantages and limitations of utilizing AI-based tools for nutritional support are then discussed. In conclusion, the integration of precision nutrition and AI presents transformative opportunities for personalized health. By harnessing the computational power of AI, researchers and healthcare practitioners can unlock the potential of large-scale data analysis for tailored dietary interventions.

Keywords: nutrition; health; diet; medicine; artificial intelligence

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1. Introduction

Precision nutrition and artificial intelligence (AI) are converging to revolutionize personalized health. In particular, precision nutrition holds the potential to optimize health by tailoring dietary interventions to individuals based on their genetics, lifestyle, and physiology [1,2], while AI, with its computational power, enables the analysis of complex data and generates actionable insights for personalized nutrition [3,4]. AI-based tools can be used for dietary intake monitoring, activity tracking, metabolic health, bodyweight control, and nutritional management of chronic diseases [1].

This literature review aims to describe the potential perspectives and limitations of AI uses in nutritional sciences.

2. Methods

PubMed was searched up until June 2023 to identify clinical studies focusing on AI dietary apps used in precision nutrition. The search strategy involved combining keywords such as "diet," "nutrition," "artificial intelligence," "machine learning," and "deep learning." Only articles written in English and labeled as clinical trials were considered for inclusion in this literature overview. The following PICOS criteria were applied:

Population (P): healthy individuals or patients diagnosed with a specific disease according to internationally recognized clinical standards.

Intervention (I): implementation of AI-based tools for precision nutrition, including controlling nutrient intake, monitoring dietary habits, and providing personalized

healthy eating tips. Special attention was given to mobile applications due to their widespread use and easy accessibility among the general population [5].

Comparison (C): any type of control, including the absence of a control group.

Outcomes (O): various clinical outcomes, such as compliance with nutritional and lifestyle recommendations, weight reduction, improvement in disease condition, and enhanced quality of life.

Study design (S): clinical trials.

The evidence obtained from data extraction was then synthesized in a narrative manner and critically discussed.

3. Results

After searching for relevant articles through PubMed, 198 results were found and 7 clinical studies were considered relevant for inclusion [6–12]. Table 1 provides a brief overview of the studies included in this analysis (5 randomized controlled trials, 2 crossover studies, and a pilot trial). Generally, these studies examined the potential utilization of AI mobile apps for various purposes, including regulating nutrient intake, aiding in weight loss, enhancing dietary treatments for chronic diseases, and predicting metabolic parameters. The findings of these studies revealed that the AI mobile apps, despite some limitations, exhibited an acceptable level of accuracy in accomplishing their intended tasks. Notably, when used in conjunction with standard dietary programs, the apps demonstrated particularly promising results.

Table 1. Summary of studies about AI mobile apps for precision nutrition.

Population	Intervention	Comparison	Outcomes	Study Design	Reference
102 healthy adults	An image-based dietary assessment app (Keenoa)	A 3-day food diary	The app showed acceptable relative validity for certain nutrients compared to the food diary. However, the average intake of energy, protein, carbohydrates, % fat, saturated fatty acids, and iron differed from the values recorded in the food diary.	RCT	[6]
136 healthy or diabetic adults	An image-based dietary assessment app (Keenoa)	A validated web-based food recall platform	The app showed moderate to strong relative validity against comparison for energy, macronutrient, and most micronutrient intakes analyzed in healthy adults and those with diabetes.	CS	[7]
141 overweight or obese adults	An AI dietary app (CALO mama Plus)	No intervention	Participants in the intervention group experienced a change in body weight of −2.4 ± 4.0 kg, while those in the control group had a change of −0.7 ± 3.3 kg. The app facilitated weight loss among the participants.	RCT	[8]
58 adults with IBS	An AI dietary app (Heali) +	Educational materials only	The app group showed a 24% greater reduction in total IBS symptom severity score, though not statistically	RCT (pilot)	[9]

	educational materials		significant. However, the intervention group had a twofold greater reduction in the subscore for bowel habit dissatisfaction.		
181 overweight or obese adults	An app that collects data on dietary lapses and their triggers (OnTrack) + a standard WLP	A standard WLP	The app facilitated weight loss by predicting and preventing dietary lapses. The participants assigned to the intervention group also reported considerably higher satisfaction and engagement, and algorithm accuracy was superior.	RCT	[10]
10 diabetic adults	A DLM for dynamic forecasting of blood glucose levels	None	The proposed DLM, based on mobile lifestyle data collected through a smartphone, exhibited significant accuracy in predicting the next day's glucose level, as assessed by the Clarke Error Grid and a ±10% range of the actual values.	RCT (secondary analysis)	[11]
36 female adolescents	An AI app for dietary assessment (FRANI)	A 3-day food diary	AI-assisted dietary assessment accurately estimated nutrient intake in adolescent females when compared with standard methods.	CS	[12]

Legends: CS = Crossover Study; DLM = Deep Learning Model; IBS = Irritable Bowel Syndrome; RCT = Randomized Controlled Trial; WLP = Weight Loss Program.

4. Discussion

As demonstrated in the studies described above, using AI in precision nutrition offers different advantages, showcasing its potential to improve personalized health. First of all, AI techniques excel at rapidly analyzing extensive datasets and have the capacity to handle diverse types of data, including genetics, biomarkers, diet, and lifestyle information [13]. This ability to uncover intricate relationships can aid in comprehending and better predicting the impact of nutrition on overall health. Other significant benefits include the generation of tailored dietary recommendations and the ability to monitor and adapt these recommendations in real time [14], by processing physiological data obtained from wearable devices. Moreover, AI may improve dietary compliance, a keystone in all nutritional interventions, through "gamification" [15]. Furthermore, AI can assist in developing predictive models for personalized dietary responses, which can provide valuable decision support to healthcare practitioners, enabling them to make informed choices and design nutritional interventions that are more likely to be effective [16]. Overall, the advantages of AI in precision nutrition underscore its potential to transform personalized health by providing data-driven insights, personalized recommendations, and real-time adaptation.

While the integration of precision nutrition and AI presents notable advantages, it is crucial to acknowledge the associated drawbacks. One significant concern is data reliability and quality, especially if we consider inconsistencies, errors, or biases in the datasets used to train AI models [17]. Despite the promise of personalized nutrition, AI-based systems may struggle to provide truly individualized recommendations, as they often rely on population-level data and statistical models to generate dietary guidelines, which may not fully account for an individual's unique characteristics. Ethical considerations also

arise when employing AI in precision nutrition, especially with regard to privacy and data security [18,19]. Furthermore, AI systems can lack the human touch and empathy that are vital in clinical interventions. In fact, it is demonstrated that some individuals still prefer the guidance and support of human healthcare professionals, who can address their specific needs and concerns [20]. Overreliance on technology is another challenge, and AI systems may diminish the role of human healthcare professionals, potentially reducing critical thinking, clinical judgment, and the ability to adapt interventions based on real-time feedback and patient preferences. Taken together, these disadvantages underscore the complexities and challenges associated with implementing AI in precision nutrition.

The most relevant advantages and limitations of AI in precision nutrition are summarized in Table 2.

Table 2. Advantages and limitations of AI in precision nutrition.

Advantages	Limitations
Data analysis and pattern recognition	Data reliability and quality
Personalized dietary recommendations	Lack of individualization
Real-time monitoring and adaptation	Ethical concerns
Uncovering novel insights and biomarkers	Limited human interaction
Predictive models and decision support	Overreliance on technology
Scalability and efficiency	Generalizability issues

5. Conclusions

In conclusion, the combination of precision nutrition and AI offers transformative opportunities for personalized health. By harnessing AI's computational power, researchers and healthcare practitioners can unlock the potential of large-scale data analysis for tailored dietary interventions. This study briefly highlights current advancements, challenges, and future directions, stressing the need for interdisciplinary collaboration to fully realize the potential of precision nutrition and AI in improving human health.

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References

1. Kirk, D.; Catal, C.; Tekinerdogan, B. Precision Nutrition: A Systematic Literature Review. *Comput. Biol. Med.* **2021**, *133*, 104365. https://doi.org/10.1016/j.compbiomed.2021.104365.
2. Rodgers, G.P.; Collins, F.S. Precision Nutrition-the Answer to "What to Eat to Stay Healthy". *JAMA* **2020**, *324*, 735–736. https://doi.org/10.1001/jama.2020.13601.
3. Wirtz, B.W.; Weyerer, J.C.; Geyer, C. Artificial Intelligence and the Public Sector—Applications and Challenges. *Int. J. Publ. Adm.* **2018**, *42*, 596–615. https://doi.org/10.1080/01900692.2018.1498103.
4. de Moraes Lopes, M.H.B.; Ferreira, D.D.; Ferreira, A.C.B.H.; da Silva, G.R.; Caetano, A.S.; Braz, V.N. Use of Artificial Intelligence in Precision Nutrition and Fitness. In *Artificial Intelligence in Precision Health*; Elsevier: Amsterdam, The Netherlands, 2020; pp. 465–496, ISBN 9780128171332.
5. Franco, R.Z.; Fallaize, R.; Lovegrove, J.A.; Hwang, F. Popular Nutrition-Related Mobile Apps: A Feature Assessment. *JMIR Mhealth Uhealth* **2016**, *4*, e85. https://doi.org/10.2196/mhealth.5846.

6. Ji, Y.; Plourde, H.; Bouzo, V.; Kilgour, R.D.; Cohen, T.R. Validity and Usability of a Smartphone Image-Based Dietary Assessment App Compared to 3-Day Food Diaries in Assessing Dietary Intake Among Canadian Adults: Randomized Controlled Trial. *JMIR Mhealth Uhealth* **2020**, *8*, e16953. https://doi.org/10.2196/16953.
7. Moyen, A.; Rappaport, A.I.; Fleurent-Grégoire, C.; Tessier, A.-J.; Brazeau, A.-S.; Chevalier, S. Relative Validation of an Artificial Intelligence-Enhanced, Image-Assisted Mobile App for Dietary Assessment in Adults: Randomized Crossover Study. *J. Med. Internet Res.* **2022**, *24*, e40449. https://doi.org/10.2196/40449.
8. Nakata, Y.; Sasai, H.; Gosho, M.; Kobayashi, H.; Shi, Y.; Ohigashi, T.; Mizuno, S.; Murayama, C.; Kobayashi, S.; Sasaki, Y. A Smartphone Healthcare Application, , to Promote Weight Loss: A Randomized Controlled Trial. *Nutrients* **2022**, *14*, 4608. https://doi.org/10.3390/nu14214608.
9. Rafferty, A.J.; Hall, R.; Johnston, C.S. A Novel Mobile App (Heali) for Disease Treatment in Participants With Irritable Bowel Syndrome: Randomized Controlled Pilot Trial. *J. Med. Internet Res.* **2021**, *23*, e24134. https://doi.org/10.2196/24134.
10. Forman, E.M.; Goldstein, S.P.; Crochiere, R.J.; Butryn, M.L.; Juarascio, A.S.; Zhang, F.; Foster, G.D. Randomized Controlled Trial of OnTrack, a Just-in-Time Adaptive Intervention Designed to Enhance Weight Loss. *Transl. Behav. Med.* **2019**, *9*, 989–1001. https://doi.org/10.1093/tbm/ibz137.
11. Faruqui, S.H.A.; Du, Y.; Meka, R.; Alaeddini, A.; Li, C.; Shirinkam, S.; Wang, J. Development of a Deep Learning Model for Dynamic Forecasting of Blood Glucose Level for Type 2 Diabetes Mellitus: Secondary Analysis of a Randomized Controlled Trial. *JMIR Mhealth Uhealth* **2019**, *7*, e14452. https://doi.org/10.2196/14452.
12. Nguyen, P.H.; Tran, L.M.; Hoang, N.T.; Trương, D.T.T.; Tran, T.H.T.; Huynh, P.N.; Koch, B.; McCloskey, P.; Gangupantulu, R.; Folson, G.; et al. Relative Validity of a Mobile AI-Technology-Assisted Dietary Assessment in Adolescent Females in Vietnam. *Am. J. Clin. Nutr.* **2022**, *116*, 992–1001. https://doi.org/10.1093/ajcn/nqac216.
13. Volpe, S.L. Artificial Intelligence and Precision Nutrition. *ACSMs Health Fit. J.* **2022**, *26*, 43–44. https://doi.org/10.1249/fit.0000000000000761.
14. Mortazavi, B.J.; Gutierrez-Osuna, R. A Review of Digital Innovations for Diet Monitoring and Precision Nutrition. *J. Diabetes Sci. Technol.* **2023**, *17*, 217–223. https://doi.org/10.1177/19322968211041356.
15. Orte, S.; Migliorelli, C.; Sistach-Bosch, L.; Gómez-Martínez, M.; Boqué, N. A Tailored and Engaging mHealth Gamified Framework for Nutritional Behaviour Change. *Nutrients* **2023**, *15*, 1950. https://doi.org/10.3390/nu15081950.
16. Berry, S.E.; Valdes, A.M.; Drew, D.A.; Asnicar, F.; Mazidi, M.; Wolf, J.; Capdevila, J.; Hadjigeorgiou, G.; Davies, R.; Al Khatib, H.; et al. Human Postprandial Responses to Food and Potential for Precision Nutrition. *Nat. Med.* **2020**, *26*, 964–973. https://doi.org/10.1038/s41591-020-0934-0.
17. Hong, Y.; Lian, J.; Xu, L.; Min, J.; Wang, Y.; Freeman, L.J.; Deng, X. Statistical Perspectives on Reliability of Artificial Intelligence Systems. *Qual. Eng.* **2023**, *35*, 56–78. https://doi.org/10.1080/08982112.2022.2089854.
18. Naik, N.; Hameed, B.M.Z.; Shetty, D.K.; Swain, D.; Shah, M.; Paul, R.; Aggarwal, K.; Ibrahim, S.; Patil, V.; Smriti, K.; et al. Legal and Ethical Consideration in Artificial Intelligence in Healthcare: Who Takes Responsibility? *Front. Surg.* **2022**, *9*, 862322. https://doi.org/10.3389/fsurg.2022.862322.
19. Keskinbora, K.H. Medical Ethics Considerations on Artificial Intelligence. *J. Clin. Neurosci.* **2019**, *64*, 277–282. https://doi.org/10.1016/j.jocn.2019.03.001.
20. Nadarzynski, T.; Miles, O.; Cowie, A.; Ridge, D. Acceptability of Artificial Intelligence (AI)-Led Chatbot Services in Healthcare: A Mixed-Methods Study. *Digit. Health* **2019**, *5*, 2055207619871808. https://doi.org/10.1177/2055207619871808.