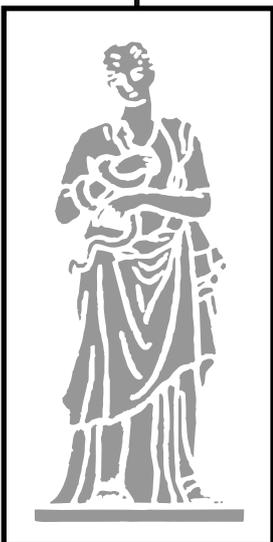


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HUMAN MILK METABOLOME: IMPACT OF GESTATIONAL AGE, LACTATION STAGE AND MATERNAL DIET

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ABSTRACT

Human breast milk due to its unique composition and the ability to adapt to the needs of the infant, is referred to as the "gold standard". Exclusive breastfeeding is recommended for the first 6 months of a infant's life. The composition of breast milk and its metabolites is not constant and varies depending on the influence of various factors. Its analysis allows for rational management of infant nutrition. Intermediate and final metabolites of human milk are formed as a result of various metabolic processes in the mammary gland, and their role and the influence of various factors on them are not fully determined in the context of the proper development of infants. Metabolomic studies can be used to identify intermediate and terminal metabolites in breast milk. The aim of the study was to review the current literature on the variability of human milk metabolome depending on factors such as gestational age, lactation stage and mother's diet. A review of current research shows that the composition of human milk metabolome varies depending on various factors. Better understanding of metabolome of breast milk could be crucial in the future programming of metabolic processes in infants, which is crucial in preventing many diseases and maintaining health.

Key words: metabolome, metabolomics, human milk, gestational age, lactation stage, maternal diet

STRESZCZENIE

Mleko matki, ze względu na swój unikalny skład i możliwość dopasowania się do potrzeb niemowlęcia, jest określane jako „złoty standard”. Wyłączne karmienie piersią zalecane jest przez pierwsze 6 miesięcy życia niemowlęcia. Skład mleka matki i jego metabolitów nie jest stały i zmienia się w zależności od wpływu różnych czynników. Jego analiza pozwala na racjonalne zarządzanie żywieniem niemowląt. Metabolity pośrednie i końcowe mleka ludzkiego powstają w wyniku różnych procesów metabolicznych w gruczole sutkowym, a ich rola i wpływ na nie różnych czynników nie są do końca określone w kontekście prawidłowego rozwoju niemowląt. Badania metabolomiczne można wykorzystać do identyfikacji pośrednich i końcowych metabolitów w mleku matki. Celem pracy był przegląd aktualnej literatury dotyczącej zmienności metabolomu mleka ludzkiego w zależności od czynników takich jak wiek ciążowy, okres laktacji i dieta matki. Przegląd aktualnych badań wskazuje na zróżnicowanie składu metabolomu mleka ludzkiego w zależności od różnych czynników. Lepsze poznanie metabolomu mleka matki może być kluczowe w przyszłym programowaniu procesów metabolicznych u niemowląt, co ma znaczenie w prewencji wielu chorób i utrzymaniu zdrowia.

Słowa kluczowe: *metabolom, metabolomika, mleko kobiece, wiek ciążowy, okres laktacji, dieta matki*

INTRODUCTION

Breastfeeding is defined as the “gold standard” in infant nutrition. Human milk is characterized by the complexity and uniqueness of its composition and provides nutrition and protection of the infant against diseases and microorganisms [36]. Human milk as a complex biological system consists of significant nutrients and bioactive components that interact

with each other to form a unique bioliquid [8]. In addition, breastfeeding ensures optimal growth and development and health of infants, being not only food, but also a source of interacting bioactive ingredients [22]. Therefore, international organizations such as the World Health Organization (WHO), the European Society of Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the American Academy of Pediatrics (AAP) recommend exclusive breastfeeding

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for the first 6 months of an infant's life, and then continuing breastfeeding as complementary foods are introduced, and breastfeeding continues for 2 years or more, as the mutual wishes of mother and infant [1, 13, 43]. The first 1000 days of life (from conception to 2 years of age) are extremely important for the proper development and prevention of diseases in the context of metabolic programming [32]. Metabolomics may be a tool that can help to understand the early health programming of infants from birth [37]. The metabolome of human milk is subject to changes depending on various factors. The identification of these factors will allow the determination and confirmation of the presence of many metabolites in breast milk that may play an important role in the prevention of metabolic diseases [6]. Due to the dynamically changing of breast milk, it is important to understand the influence of various factors on human milk metabolome. This knowledge can possibly improve and better manage infant nutrition [17].

DEVELOPMENT OF MODERN ANALYTICAL METHODS ENABLING THE DETERMINATION OF COMPOUNDS WITH SMALL MOLECULES

Metabolomics allows the analysis of small molecules and metabolites, making it a promising tool for the precise determination and understanding of intracellular metabolic pathways and biomarkers [35]. The most important groups of metabolites are amino acids, carbohydrates, nucleotides, lipids, coenzymes and cofactors, which are diverse in terms of structure and molecular structure, as well as properties and functions, posing an analytical challenge [47]. Metabolomics enables the study of the level of polar and lipid metabolites, which is the basis for understanding the pathophysiological mechanisms of metabolic diseases. Moreover, it enables the effective diagnosis of abnormal physiological processes and states, and can also be a tool for the prevention and treatment of diseases [21]. The development of modern analytical techniques for metabolomics and lipidomics has enabled the determination and identification of particles <1500 daltons [10]. The most frequently used analytical methods in metabolomics studies are nuclear magnetic resonance (NMR) and gas chromatography (GC), liquid chromatography (LC) and electrophoresis (CE) coupled with mass spectrometry (MS) [33]. The NMR technique is non-destructive and highly reproducible and automated, thanks to which it is possible to identify new compounds in particular in large-scale metabolomics studies [12]. However, the intensive development of MS techniques has made them less limited and more effective, selectable and

sensitive. Moreover, the use of MS techniques allows the identification of a large number of different polar metabolites and/or lipids in samples even in very small amounts [15]. Currently, technological advances in the field of metabolomics reduce the difficulty of carrying out analyzes and reduce their costs [14]. Most of the current metabolomics and lipidomics studies are based on non-targeted analysis, which is free from hypotheses and allows to increase the knowledge about the unique composition of human milk and its metabolites [41]. Due to the complexity of the composition of human milk, the use of multiple analytical platforms allows the determination of as many metabolites as possible, which is often impossible using only one method [2]. It is worth emphasizing that the composition of breast milk is dynamic changes in both lactation progression and single feeding to cover the nutritional needs of the child, therefore the appropriate methods of its analysis should be selected [26]. In addition, metabolic processes taking place in the mammary gland result in the formation of intermediate and final metabolites of human milk, the role of which, as well as the influence of various factors on them, are not fully defined in the context of health and proper development of infants [29].

FACTORS INFLUENCING HUMAN MILK METABOLOME

Gestational age

According to a WHO report, it is estimated that approximately 15 million babies are born prematurely (before the 37th week of pregnancy) each year. This indicates that more than 1 in 10 infants are born preterm [42]. Nutrition of premature infants should be primarily aimed at achieving a postnatal growth rate similar to term infants [19]. Breastfeeding has invaluable benefits not only for healthy infants, but also for preterm infants. Breast milk feeding reduces the risk of necrotizing enterocolitis (NEC) and sepsis, and improves the neurological development of preterm infants [1]. Gestation age is one of the factors influencing the diversification of the human milk metabolome. Analysis of milk metabolome of preterm mothers may help to better understand changes in metabolite composition compared to the milk of full-term infants. Moreover, it may bring benefits from understanding the nutritional needs of preterm infants, which would help maintain an adequate nutritional status of this particularly vulnerable group [48]. *Sundekilde* et al. [40] investigated the effect of gestational age on metabolome of human milk. Milk samples were collected from 15 mothers of preterm infants, while 30 milk samples were collected from mothers who gave birth at term. Depending on the postpartum time, milk samples were divided into 3

categories: colostrum (<5 days postpartum; n = 5), transitional milk (6 days - 2 weeks postpartum; n = 4) and mature milk (> 2 weeks, n = 21). Milk metabolomes were compared by proton nuclear magnetic resonance (^1H NMR) spectroscopy. Comparing the metabolome of breast milk obtained from mothers of premature infants and mothers of full-term infants, it was found differences in the concentrations of carnitine, caprylate, caprate, pantothenate, urea, lactose, oligosaccharides, citrate, phosphocholine, choline and formate were noted. The gestational age can significantly affect the oligosaccharide content in human milk. In the study by *Perrone et al* [31], nuclear magnetic resonance (NMR) spectroscopy also was used to identify metabolites. In total, 18 mothers were recruited for the study: 6 mothers who gave birth to premature babies (from 29 to 31 weeks GA) and 12 mothers who gave birth at term. Higher concentrations of lactose and oligosaccharides, especially fucosylated, such as fucose, N-acetylneuraminic acid and N-acetylglucosamine were identified in the milk of premature infants compared to mothers of full-term infants. Changes in metabolomic profiles of milk of preterm infants may indicate different nutritional requirements of these babies. Another comparison between the metabolomic profile of milk of preterm mothers and milk of full-term mothers was performed by *Xu et al.* [46]. Lipidomic profiles were identified by liquid chromatography coupled with tandem mass spectrometry (LC-MS / MS). Colostrum samples were collected for the study from healthy mothers of preterm breastfeeding infants and mothers of full-term breastfeeding infants. Colostrum of premature mothers was characterized by a higher concentrations of phosphatidylethanolamine and phosphatidylcholine, as well as lower concentrations of diacylglycerol and ceramide compared to the milk of mothers who gave birth at term. *Spevacek et al.* [39] conducted a prospective observational study involving mothers of both term and premature babies. Human milk samples were collected 0-5 days postpartum and then 14-28 days later. ^1H NMR was used to identify and quantify human milk metabolome. The colostrum samples were rich in 3'-galactosyllactose (3'-GSL), 2-hydroxybutyrate, methionine and acetoin, but their amount decreased in term milk. Dimethylsulfone was also identified, it was characterized by a low content in the colostrum, while its concentration increased during the first month of lactation. Regardless of the age of pregnancy, the total concentration of oligosaccharides decreased during lactation. Interestingly, the concentrations of some amino acids and derivatives in breast milk also were changed. There was an increase in 2-aminobutyrate, alanine, carnitine, glutamate, glutamine, histidine, urea and valine, in contrast to the milk of mothers of premature infants. The

concentration of fatty acids and their metabolites also changed, and an increase in lactose concentration was observed during the first month of lactation, both in preterm milk and in term milk. The study by *Longini et al.* [24] recruited 20 mothers who gave birth at 23-41 weeks of pregnancy, from whom 46 samples of human milk were collected. The metabolites of preterm and term milk were compared as well as formula milk. For metabolomic analysis, proton magnetic resonance spectroscopy (MRS) was used to determine water-soluble and lipid fractions extracted from human milk. Apart from noting changes between human milk and formula milk, the study found significant differences between the milk samples of mothers giving birth at 23-25 weeks of gestation compared to the milk of mothers giving birth at 29 weeks of gestation. A study by *Peila et al.* [30] recruited 36 breastfeeding mothers who gave birth prematurely between 23 and 33 weeks of gestation. In addition, three groups of mothers were distinguished according to different gestational age (GA): extreme (<28 GA week), very (29-31 GA week) or moderate (32-34 GA week). The milk samples were colostrum, transitional milk, and mature milk, metabolome of which was examined using nuclear magnetic resonance (NMR) spectroscopy. Depending on the gestational age, when comparing groups of extremely and moderately premature infants, the study showed significant but weak changes in the concentrations of some metabolites.

Lactation stage

Factors related to the time of feeding have a significant impact on metabolomic profile due to changes related to three main stages of lactation: colostrum, transitional milk and mature milk [4]. Colostrum, which is the first milk of the mother, is a rich source of active immunological substances and proteins [28]. Transitional milk is characterized by accelerated production in order to meet the infant's needs for its proper development and growth as much as possible. Mature milk is milk similar to transitional milk, but it is more stable [45].

Recent studies confirm the differentiation of metabolome of human milk depending on the stage of lactation. In the study by *Wu et al.* [44], nuclear magnetic resonance (NMR) spectroscopy was used to identify and quantify metabolites. Human milk samples were collected from a healthy 37-year-old woman (BMI = 24) in the morning and evening on days 9, 12, 24, 31, 60, 85, 86 and 87 (only the morning sample was taken on the last day). Human milk metabolomes in the early (9-24 days postpartum) and late (31-87 days postpartum) stages of lactation were statistically significantly different. The late stage of lactation was characterized by significantly increased concentrations of lactose, choline, alanine,

glutamate and glutamine, and decreased levels of citrate, phosphocholine, glycerophosphocholine and N-acetylglucosamine. The weakness of the study was that a sample was only tested from one person. Additionally, the effect of the storage time of the milk samples at the temperature of 20°C or 80°C was investigated, however, no significant differences in metabolome of human milk were found. The study by *Sundekilde et al.* [40] involved 45 women, including 15 mothers of preterm breastfeeding infants and 30 mothers of full-term breastfeeding infants. Milk metabolome was studied using proton nuclear magnetic resonance (¹H-NMR) spectroscopy. In the colostrum of mothers of full-term infants, higher concentrations of valine, leucine, betaine and creatinine were found compared to mature milk. On the other hand, in mature milk a higher concentration of glutamate, caprylate and caprate was observed than in the colostrum of mothers of full-term infants. Mothers of premature infants had higher levels of oligosaccharides, citrate, and creatinine in the colostrum, while higher levels of caprylate, caprate, valine, leucine, glutamate and pantothenate were noted with time after delivery. Data on changes in metabolome of human milk was provided by a study by *Giuffrida et al.* [18] among Chinese breastfeeding mothers. 540 healthy, breastfeeding women were recruited for the study and gave birth to one child at term. The milk was sampled over a period of eight months. Fatty acids were determined by gas chromatography coupled to a flame ionization detector (GC-FID), phospholipid classes were determined using liquid chromatography with evaporative light scattering detector (LC-ELSD), and for the determination of gangliosides, liquid chromatography with tandem mass spectrometry (LC-MS/MS). As a result, an increased content of polyunsaturated fatty acids (PUFA) and gangliosides (GD) was found in later stages of lactation. On the other hand, the concentration of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and phospholipids (PL) decreased during lactation. The study by *Azad et al.* [3] included the analysis of various factors influencing the variability in the human milk oligosaccharides (HMO) in 427 mother-child dyads, whose milk samples were delivered 3-4 months after delivery. The study focused on the content and type of HMO isolated by high-throughput solid phase extraction followed by HPLC analysis with fluorescence detection. HMO content was lower with longer lactation times in line with earlier literature, however, the study showed that disialyllacto-N-tetraose (DSLNT) and 3'-sialyllactose (3'-SL) concentrations were higher later in lactation. The metabolomic analysis performed using high-performance liquid chromatography-quadrupole-time of flight mass spectrometry (HPLC-QTOF-MS) in the

study by *Li et al.* [23] was aimed at assessing changes in human milk metabolites during the lactation stages. Thirty healthy breastfeeding women were recruited for the study, from whom milk samples were collected at three stages of lactation (colostrum, transitional milk and mature milk) on days 1, 14 and 42 postpartum, respectively. In the study, a total of 84 metabolites were identified in the three stages of lactation. The longer the duration of lactation, the concentration of 9 dipeptides increased, such as: glycyl-valine, histidinyl-threonine, lysyl-threonine, threonyl-tyrosine, tyrosyl-glutamine, tyrosyl-serine, valylvaline, valyl-alanine and histidinyl-histidine. There was also an increase in concentration of eicosanoid (prostaglandin E3), 1 fatty amide (octadecanamide) and 2 fatty esters (CE (15:1) and CE (14:0)), as well as free fatty acids: C10:0, C11:0, C14:0, C16:1n-7, C17:0, C18:1n-9 and C18:2n-6. Moreover, with longer lactation time, an increase in the concentration of 12 diacylglycerols in human milk was also noted DG (14:0/20:4n-6), DG (14:0/24:1n-9), DG (14:1n-5/18:3n-3), DG (15:0/20:4n-6), DG (18:0/18:1n-9), DG (18:4n-3/18:4n-3), DG (20:0/24:1n-9), DG 24:0/15:0), DG (18:3n-3/18:3n-3), DG (15:0/16:1n-7) and DG (14:0/14:1n-5). In addition, along with the longer lactation time, content of 11β-hydroxyprogesterone, cisaconitic acid and spermidine increased significantly, as well as nucleotides such as: 6-succinaminopurine, deoxyuridine, dUMP, purine and AMP 3'-phosphate. During the study, 7 vitamins were detected, of which the content of vitamin D3, 1,24,25-(OH)3, vitamin D3, 25-hydroxyvitamin D2-25-glucuronide, vitamin D2 and biotin was positively associated with the lactation time, while the content of β-glucuronide retinoil and γ-tocopherol significantly decreased. The innovative use of a multiplatform approach combining HPLC-MS and ultra-performance LC-MS, GC-MS, CE-MS, and 1H NMR spectroscopy in the study by *Andreas et al.* [2] allowed for comprehensive identification and evaluation of metabolite changes in breast milk samples during lactation. Metabolomic profiling was performed on 70 samples of human milk collected between 2 and 80 postpartum, from 57 women who gave birth to healthy infants on time. The metabolites present in human milk changed dynamically during the first 3 months of lactation. At the beginning of lactation, an increase in the content of di- and tri-acylglycerols as well as lactose, some amino acids and short- and medium-chain fatty acids was noted. On the other hand, with increasing lactation time, many human milk oligosaccharides (HMOs), some phosphocholines as well as citrate and pyruvate decreased.

Factors related to maternal health and lifestyle

Maternal factors may play one of the key roles in shaping the metabolome of human milk. Factors such

as diet, nutritional status or maternal diseases and medical condition may have a significant effect on the increase or reduction of the concentration of certain metabolites in human milk.

Maternal diet

Maternal nutrition is one of the key factors influencing metabolome of human milk. Metabolomics can help to improve knowledge about the relationship between the nutritional status and metabolites found in body fluids, such as breast milk [27]. The study by *Smilowitz et al* [38] was aimed at examining the metabolome of breast milk depending on the phenotype and maternal diet. NMR technique was used to determine the metabolites. Metabolites such as mono-, di- and oligosaccharides, amino acids and derivatives, energy metabolites, fatty acids and related metabolites as well as vitamins, nucleotides and derivatives and others have been quantified. The following metabolites showed the greatest variability in breast milk: 2'-FL, fucose, LDFT, LNFP I, LNFP II, aspartate, lysine, proline, acetone, creatine phosphate, fumarate, acetate, azelate, butyrate, choline, niacinamide, hypoxanthine, formate and methanol. In addition, essential nutrients that come with the diet such as choline, niacinamide, ascorbate and pantothenate have also undergone various changes. Metabolomic analysis in the study by *Li et al.* [23] was carried out using HPLC-QTOF-MS technique. Eighty four metabolites were identified in the study, however only two were of dietary significance; the concentration of 1,24,25- (OH) 3 of vitamin D3 was positively associated with the consumption of meat and eggs, protein and fat in the diet, while the concentration of 11 β -hydroxyprogesterone was negatively associated with the intake of fruit and carbohydrates in diet.

A study by *Marín et al.* [25] investigated the relationship between maternal nutrition and fatty acid composition of milk. 46 breastfeeding mothers who gave birth to healthy, full-term infants at 38-42 weeks of pregnancy were recruited for the study. Maternal nutritional status was assessed using body mass index (BMI), while maternal nutrition was assessed using the eating frequency questionnaires (FFQ). The questionnaire included questions about amount and frequency of consumption of high-fat foods per week (including whole milk and derivatives, fried meat, eggs, chocolate candies), as well as low-fat foods (including rice and other grains, vegetables and fruits, skim milk, low-fat fish, bread). The study did not show any effect of maternal nutritional status on human milk proteins. However, higher levels of lipids, linoleic acid and total n-6 acids and PUFA were observed in obese mothers.

Maternal overweight/obesity

Overweight and obesity are becoming a growing problem worldwide, posing a challenge to public health. Obesity may lead to the development of metabolic changes, causing e.g. diabetes, dyslipidemia, arterial hypertension, cancer or changes in the intestinal microbiota [5]. Although prevalence of obesity among children is lower than among adults, the rate of its spread is higher [16]. Maternal obesity before and during pregnancy may be associated with a higher prevalence of obesity in children [7]. Infants who are constantly exposed to factors related to maternal obesity may develop health problems later in life. Determining the milk metabolome of obese mothers can help prevent infant obesity later by ensuring optimal and sustainable growth and development. A study by *Saben et al* [34] aimed to assess the effect of maternal obesity on metabolome of human milk and to identify milk metabolites associated with infant obesity. Healthy women with BMI 18.5-24.9 were recruited for the study, divided into a group of obese and non-obese mothers. Human milk metabolome determination was performed using GC-time-of-flight-MS (GC-TOF-MS). The study showed that maternal obesity is related to metabolome of human milk, which is richer in monosaccharides and sugar alcohols compared to milk of non-obese mothers. The content of human milk monosaccharides, mannose and ribose as well as sugar alcohols, lxitol and ribitol were higher in mothers with higher BMI. Another study by *Isganaitis et al.* [20] analyzed the metabolome of breast milk in terms of its relationship to maternal obesity. For this purpose, non-directional liquid chromatography, gas chromatography and mass spectrometry were used. Six months after delivery, higher levels of acylcarnitines, monosaccharides and sugar alcohols in milk were noted in obese mothers, while the amount of amino acids and their metabolites decreased. This suggests association between obesity and changes in metabolome of human milk. The study by *De Luca et al.* [9] was aimed at determining changes in the concentration of free amino acids depending on obesity of a breastfeeding mother. Free amino acid (FAA) concentrations in breast milk were determined by ultra-performance liquid chromatography tandem mass spectrometry. The breast milk of the obese mothers contained more branched chain amino acids (BCAA) and more tyrosine than the milk of not obese mothers.

A study by *Ellsworth et al.* [11] compared changes in composition of milk from overweight and obese mothers to non-obese mothers. In milk of overweight and obese mothers the increase of long-chain polyunsaturated fatty acids (LC-PUFA) and the decrease of oleic acid (C18:1n-9) and conjugated linoleic acid (CLA) was found. Additionally, increased level of insulin also was noted.

CONCLUSIONS

The composition of each mother's milk is personalized depending on the needs of the infant. Mother's milk is a unique bioliquid with unique properties, ensuring proper development and growth for infants. More research and application of various extraction and analysis techniques are needed to understand the influence of various factors on the composition and metabolic profile of human milk. It is especially important to study the influence of the diet of pregnant and breastfeeding women on the metabolome of breast milk, because this is a factor that can be relatively easily modified.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. American Academy of Paediatrics. Breastfeeding and use of human milk. *Pediatrics* 2012;129:e827–e841.
2. *Andreas N.J., Hyde M.J., Gomez-Romero M., Lopez-Gonzalez M.A., Villaseñor A., Wijeyesekera A., Barbas C., Modi N., Holmes E., Garcia-Perez I.*: Multiplatform characterization of dynamic changes in breast milk during lactation. *Electrophoresis* 2015;36(18):2269-2285.
3. *Azad M.B., Robertson B., Atakora F., Becker A.B., Subbarão P., Moraes T.J., Mandhane P.J., Turvey S.E., Lefebvre D.L., Sears M.R., Bode L.*: Human Milk Oligosaccharide Concentrations Are Associated with Multiple Fixed and Modifiable Maternal Characteristics, Environmental Factors, and Feeding Practices. *J Nutr* 2018;148(11):1733-1742.
4. *Ballard O., Morrow A.L.*: Human milk composition: nutrients and bioactive factors. *Pediatr. Clin. N. Am.* 2013;60(1):49-74.
5. *Barakat B., Almeida M.E.F.*: Biochemical and immunological changes in obesity. *Arch Biochem Biophys.* 2021;708:108951. doi: 10.1016/j.abb.2021.108951.
6. *Bardanzellu F., Fanos V., Reali A.*: "Omics" in Human Colostrum and Mature Milk: Looking to Old Data with New Eyes. *Nutrients.* 2017;9(8):843. doi:10.3390/nu9080843.
7. *Castillo-Laura H., Santos I.S., Quadros L.C., Matijasevich A.*: Maternal obesity and offspring body composition by indirect methods: a systematic review and meta-analysis. *Cad Saude Publica.* 2015;31(10):2073-2092.
8. *Christian P., Smith E.R., Lee S.E., Vargas A.J., Bremer A.A., Raiten D.J.*: The need to study human milk as a biological system. *Am J Clin Nutr.* 2021;113(5):1063-1072.
9. *De Luca A., Hankard R., Alexandre-Gouabau M.C., Ferchaud-Roucher V., Darmaun D., Boquien C.Y.*: Higher concentrations of branched-chain amino acids in breast milk of obese mothers. *Nutrition.* 2016;32(11-12):1295-1298.
10. *Demmelmair H., Koletzko B.*: Variation of Metabolite and Hormone Contents in Human Milk. *Clin Perinatol.* 2017;44(1):151-164.
11. *Ellsworth L., Perng W., Harman E., Das A., Pennathur S., Gregg B.*: Impact of maternal overweight and obesity on milk composition and infant growth. *Matern Child Nutr.* 2020;16(3):e12979. doi:10.1111/mcn.12979.
12. *Emwas A.-B., Roy R., McKay R.T., Tenori L., Saccenti E., Gowda G.A.N., Raftery D., Alahmari F., Jaremko L., Jaremko M., Wishart D.S.*: NMR Spectroscopy for Metabolomics Research. *Metabolites* 2019;9:123. doi: 10.3390/metabo9070123.
13. ESPGHAN Committee on Nutrition. *Agostoni C., Braegger C., Decsi T., Kolacek S., Koletzko B., Michaelsen K.F., Mihatsch W., Moreno L.A., Puntis J., Shamir R., Szajewska H., Turck D., van Goudoever J.*: Breast-feeding: A commentary by the ESPGHAN Committee on Nutrition. *J Pediatr Gastroenterol Nutr.* 2009;49(1):112-25.
14. *Fuhrer T., Zamboni N.*: High-throughput discovery metabolomics. *Curr. Opin. Biotechnol.* 2015;31:73–8.
15. *Gallart-Ayala H., Teav T., Ivanisevic J.*: Metabolomics meets lipidomics: Assessing the small molecule component of metabolism. *Bioessays* 2020;42(12).
16. GBD 2015 Obesity Collaborators, *Afshin A., Forouzanfar M.H., et al.* Health Effects of Overweight and Obesity in 195 Countries over 25 Years. *N Engl J Med.* 2017;377(1):13-27.
17. *George A.D., Gay M.C.L., Trengove R.D., Geddes D.T.*: Human Milk Lipidomics: Current Techniques and Methodologies. *Nutrients.* 2018;10(9):1169. doi:10.3390/nu10091169
18. *Giuffrida F., Cruz-Hernandez C., Bertschy E., Fontannaz P., Masserey Elmelegy I., Tavazzi I., Marmet C., Sanchez-Bridge B., Thakkar S.K., De Castro C.A., Vynes-Pares G., Zhang Y., Wang P.*: Temporal Changes of Human Breast Milk Lipids of Chinese Mothers. *Nutrients.* 2016;8(11):715 doi:10.3390/nu8110715.
19. *Hay W.W.*: Strategies for feeding the preterm infant. *Neonatology* 2008;94(4):245-254.
20. *Isganaitis E., Venditti S., Matthews T.J., Lerin C., Demerath E.W., Fields D.A.*: Maternal obesity and the human milk metabolome: associations with infant body composition and postnatal weight gain. *Am J Clin Nutr.* 2019;110(1):111-120.
21. *Johnson C.H., Ivanisevic J., Siuzdak G.*: Metabolomics: beyond biomarkers and towards mechanisms. *Nat Rev Mol Cell Biol.* 2016;17(7):451-459.
22. *Koletzko B., Godfrey K.M., Poston L., Szajewska H., van Goudoever J.B., de Waard M., Brands B., Grivell R.M., Deussen A.R., Dodd J.M., Patro-Golab B., Zalewski B.M.*: Early Nutrition Project Systematic Review Group: Nutrition during pregnancy, lactation, and early childhood and its implications for maternal and long-term child health: the Early Nutrition Project recommendations. *Ann. Nutr. Metab.* 2019;74:93-106.
23. *Li K., Jiang J., Xiao H., Wu K., Qi C., Sun J., Li D.*: Changes in the metabolite profile of breast milk over lactation stages and their relationship with dietary intake

- in Chinese women: HPLC-QTOFMS based metabolomic analysis. *Food Funct.* 2018;9(10):5189-5197.
24. Longini M., Tataranno M.L., Proietti F., Tortoriello M., Belvisi E., Vivi A., Tassini M., Perrone S., Buonocore G.: A metabolomic study of preterm and term human and formula milk by proton MRS analysis: preliminary results. *J Matern Fetal Neonatal Med.* 2014;27Suppl2:27-33.
25. Marín M.C., Sanjurjo A., Rodrigo M.A., de Alaniz M.J.: Long-chain polyunsaturated fatty acids in breast milk in La Plata, Argentina: relationship with maternal nutritional status. *Prostaglandins Leukot Essent Fatty Acids.* 2005;73(5):355-360.
26. Marincola F.C., Dessì A., Corbu S., Reali A., Fanos V.: Clinical impact of human breast milk metabolomics. *Clin Chim Acta* 2015;451(Pt A):103-6.
27. McNiven E.M., German J.B., Slupsky C.M.: Analytical metabolomics: nutritional opportunities for personalized health. *J Nutr Biochem.* 2011;22(11):995-1002.
28. Munblit D., Treneva M., Peroni D.G., Colicino S., Chow L., Dissanayeke S., Abrol P., Sheth S., Pampura A., Boner A.L., Geddes D.T., Boyle R.J., Warner J.O.: Colostrum and Mature Human Milk of Women from London, Moscow, and Verona: Determinants of Immune Composition. *Nutrients* 2016;8(11):695. doi: 10.3390/nu8110695.
29. Ojo-Okunola A., Cacciatore S., Nicol M.P., du Toit E.: The Determinants of the Human Milk Metabolome and Its Role in Infant Health. *Metabolites* 2020;10(2):77.
30. Peila C., Sottemano S., Maricola F.C., Stocchero M., Pusceddu N.G., Dessì A., Baraldi E., Fanos V., Bertino E.: NMR Metabonomic Profile of Preterm Human Milk in the First Month of Lactation: From Extreme to Moderate Prematurity. *Foods* 2022;11(3):345 doi:10.3390/foods11030345.
31. Perrone S., Longini M., Zollino I., Bazzini F., Tassini M., Vivi A., Bracciali C., Calderisi M., Buonocore G.: Breast milk: To each his own. From metabolomic study, evidence of personalized nutrition in preterm infants. *Nutrition* 2019;62:158-161.
32. Poulsen K.O., Sundekilde U.K.: The Metabolomic Analysis of Human Milk Offers Unique Insights into Potential Child Health Benefits, *Curr. Nutr. Rep.* 2021;10:12-29.
33. Qian L., Zhao A., Zhang Y., Chen T., Zeisel S.H., Jia W., Cai W.: Metabolomic Approaches to Explore Chemical Diversity of Human Breast-Milk, Formula Milk and Bovine Milk. *Int. J. Mol. Sci.* 2016;17(12):2128. doi.org/10.3390/ijms17122128.
34. Saben J.L., Sims C.R., Piccolo B.D., Andres A.: Maternal adiposity alters the human milk metabolome: associations between nonglucose monosaccharides and infant adiposity. *Am. J. Clin. Nutr.* 2020;112(5):1228-1239.
35. Shadid M., Yeon A., Kim J.: Metabolomic and lipidomic approaches to identify biomarkers for bladder cancer and interstitial cystitis. *Mol Med Rep.* 2020;22(6):5003-5011.
36. Singh K.S., Singh B.P., Rokana N., Singh N., Kaur J., Singh A., Panwar H.: Bio-therapeutics from human milk: prospects and perspectives. *J. Appl. Microbiol* 2021. doi.org/10.1111/jam.15078.
37. Slupsky C.M.: *Metabolomics in Human Milk Research.* Nestle Nutr Inst Workshop Ser. 2019;90:179-190.
38. Smilowitz J.T., O'Sullivan A., Barile D., German J.B., Lönnerdal B., Slupsky C.M.: The human milk metabolome reveals diverse oligosaccharide profiles. *J Nutr.* 2013;143(11):1709-1718.
39. Spevacek A.R., Smilowitz J.T., Chin E.L., Underwood M.A., German J.B., Slupsky C.M.: Infant Maturity at Birth Reveals Minor Differences in the Maternal Milk Metabolome in the First Month of Lactation. *J Nutr.* 2015;145(8):1698-1708.
40. Sundekilde U.K., Downey E., O'Mahony J.A., O'Shea C.A., Ryan C.A., Kelly A.L., Bertram H.C.: The Effect of Gestational and Lactational Age on the Human Milk Metabolome. *Nutrients* 2016;8(5):304. doi:10.3390/nu8050304.
41. Ten-Doménech I., Ramos-Garcia V., Piñeiro-Ramos J. D., Gormaz M., Parra-Llorca A., Vento M., Kuligowski J., Quintás G.: Current Practice in Untargeted Human Milk Metabolomics. *Metabolites* 2020;10(2):43. doi: 10.3390/metabo10020043.
42. World Health Organization (WHO). Available <https://www.who.int/news-room/fact-sheets/detail/preterm-birth> (Accessed 13.04.2022).
43. World Health Organization, UNICEF. Global strategy for infant and young child feeding. World Health Organization. 2003.
44. Wu J., Domellöf M., Zivkovic A.M., Larsson G., Öhman A., Nording M.L.: NMR-based metabolite profiling of human milk: A pilot study of methods for investigating compositional changes during lactation. *Biochem Biophys Res Commun.* 2016;469(3):626-32.
45. Wu X., Jackson R.T., Khan S.A., Ahuja J., Pehrsson P.R.: Human Milk Nutrient Composition in the United States: Current Knowledge, Challenges, and Research Needs. *Curr Dev Nutr.* 2018;2(7):nzy025. doi:10.1093/cdn/nzy025.
46. Xu L., Chen W., Yu Z., Han S.: Comparative Lipidomic Analyses Reveal Different Protections in Preterm and Term Breast Milk for Infants. *Front Pediatr.* 2020;8:590. doi:10.3389/fped.2020.00590.
47. Yang P.L.: Metabolomics and Lipidomics: Yet More Ways Your Health Is Influenced by Fat. *Viral Pathogenesis* 2016;181-198.
48. Zhang Z., Adelman A.S., Rai D., Boettcher J., Lönnerdal B.: Amino acid profiles in term and preterm human milk through lactation: a systematic review. *Nutrients.* 2013;5(12):4800-4821.

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ALTERNATIVE AND ONLINE WEIGHT LOSS INTERVENTIONS DURING COVID-19 PANDEMIC LOCKDOWN

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ABSTRACT

The problem of obesity is affecting an increasing number of people worldwide. The COVID-19 pandemic and the required social distancing, which make it impossible to see a dietitian, present new challenges and require the development of new ways of working with overweight individuals. Based on research and practice, dietetic services are beginning to shift from in-office consultations to a form of online consultation using mobile apps and websites. This literature review aims to critically analyze the scientific evidence for the effectiveness of interventions targeting weight loss in overweight or obese individuals focusing on behavioral and online interventions. The data from the presented studies suggest that the effectiveness of online interventions to control body weight is high enough to be used in nutritional education and in weight reduction or maintenance. The main advantage is a wide access to them for the public.

Key words: *obesity, Covid-19 pandemic, nutritional education, online dietetic consultations, online body weight interventions, weight loss*

STRESZCZENIE

Problem otyłości dotyka coraz większej grupy ludzi na całym świecie. Pandemia COVID-19 oraz narzucony dystans społeczny, uniemożliwiający spotkanie z dietetykiem, stawiają przed nami nowe wyzwania i wymagają wypracowania nowych sposobów współpracy z osobami z nadmierną masą ciała. W oparciu o badania naukowe i praktykę usługi dietetyczne zaczynają przechodzić z konsultacji stacjonarnych na formę konsultacji on-line, wykorzystując aplikacje mobilne i strony internetowe. Ten przegląd literatury ma na celu krytyczną analizę dowodów naukowych na skuteczność interwencji ukierunkowanych na zmniejszenie masy ciała u osób z nadwagą lub otyłością skupiając się na interwencjach behawioralnych i interwencjach online. Dane z przytoczonych badań sugerują, że skuteczność interwencji internetowych w celu kontroli masy ciała jest wystarczająco wysoka, aby opłacać się zarówno w edukacji żywieniowej, jak i redukcji czy utrzymaniu masy ciała. Główną zaletą konsultacji internetowych dla społeczeństwa, jest szeroki do nich dostęp.

Słowa kluczowe: *otyłość, pandemia Covid-19, edukacja żywieniowa, dietetyczne konsultacje online, zmniejszenie masy ciała, interwencje online*

INTRODUCTION

The problem of obesity is affecting an increasing number of people worldwide. In 2016, 1.9 billion adults struggled with being overweight and of those, 650 million were obese. Additionally, as reported in a 2019 report, 38.2 million children under the age of 5 are overweight or obese - a number that is estimated to continue to rise for children as well as adults [1]. In many countries, interventions to inhibit the spread of Coronavirus disease 2019 (COVID-19) have led to a worsening of the economic situation in society.

This is in turn reflected in worsening socio-economic inequality as in any financial crisis [2]. Considering the relationship between the economic status of societies and the risk of obesity, it can be suspected that the epidemic of obesity and its associated diseases will grow even faster [3]. One of the explanations for this trend is the preference of people with lower economic status for cheaper, energy-rich, tasty and easily accessible foods, and these types of foods promote the risk of obesity [4, 5]. Interestingly, a review paper published in *Obesity Reviews* in 2021 argues that top-down interest in solving the obesity problem is

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higher the more the public perceives obesity as an environmental rather than an individual problem. This paper highlights the need to support non-stigmatizing policies about obesity to contribute to a broader discussion of the problem [6]. In addition, it is worth noting that the isolation imposed by many countries promotes reduced spontaneous and planned physical activity. Since the first quarter of 2020, fitness clubs and other places for physical activity have been closed either periodically or permanently. There are many scientific publications confirming the positive impact of an increased physical activity on reducing the risk of obesity [7, 8, 9]. For the prevention of overweight and obesity, 2.5 h per day of energy expenditure in the form of Non Exercise Activity Thermogenesis (NEAT) (e.g. standing, moving, walking) is recommended. Increasing NEAT as a means of weight maintenance may also have a positive effect on metabolic adaptation resulting from a low-calorie diet and provide an alternative method of weight control [10]. Interestingly, to date, there is a lack of strong evidence that obesity risk is associated with consumption of a particular food group. A 2019 meta-analysis analyzing the results of studies examining the association between intake of given food groups and obesity risk found that the results of the correlations provided very low or low-quality evidence that certain foods affect obesity risk. At the same time, the authors point out that research in this direction should continue, as we have hypotheses that support this relationship [11].

Increased psychosocial insecurities and thus increased levels of psychological stress in the population may also be related to an increased obesity risk. *Bjorntorp's* [12] work found that psychosocial reactions to stress promote an increased energy intake with diet. Additionally, individuals with limited social interactions are more likely to develop obesity [13]. The above hypotheses appear to be supported by the first work analyzing the physical well-being of individuals affected by COVID-19 restrictions [14]. In a study involving 183 subjects, an increase in body weight of 0.63 ± 3.7 kg was observed in 49.18% as a result of decreased physical activity and increased food intake. In addition, a decrease in PAL was observed from 1.64 ± 0.15 to 1.58 ± 0.13 , as well as changes in the amount of food and specific food groups consumed, including alcohol [15]. The problem of obesity is not only associated with an increased mortality or disease risk. *Kolotkin and Andersen* [16], based on a meta-analysis of studies, demonstrate an association between an increased body mass index (BMI) and decreased health-related quality of life (HRQoL). In addition, this relationship was also demonstrated after bariatric surgery, after which weight loss in the subjects was associated with a significant improvement in this indicator of life satisfaction.

In conclusion, there are many indications of the growing problem of obesity in the world. Due to this trend, it seems necessary to develop effective methods of treatment and prevention of obesity in the world and research in this direction should be a priority [17]. The possible increase in the pandemic of obesity seems to have a clear connection with the lockdowns that are taking place, which indicates the need to look for more and better ways to help people with excessive body weight to reduce it and maintain it at an optimal BMI level. This literature review aims to critically analyze the scientific evidence for the effectiveness of interventions targeting weight reduction in overweight or obese individuals.

MATERIALS AND METHODS

Scientific publications developed in English published between 2000 and 2021 were used for data analysis using databases: PubMed, Google Scholar, Medline, Scopus and Web of Science. The following keywords combined with operators NOT, OR, AND were used: Intervention, Randomization, Adults, Humans, Energy Restriction, Reduction energy, Lose weight, Lose fat, Overweight, Online, Computer study, Nutrition, Diet, Health promotion, Health behavior, Obesity surgery, Obesity treatment.

Articles published in peer-reviewed scientific journals were included in the review. Two reviewers independently assessed articles for inclusion in the review, initially based on title and abstract. Full texts were then retrieved and evaluated for inclusion.

Inclusion criteria were intervention studies or original literature reviews as well as systematic reviews of the literature on the prevention and treatment of obesity bringing new and innovative insights into the latest tools aimed at supporting weight loss. The papers published prior to 2000 on patients, pregnant and lactating women, children, and adolescents were excluded. After analysis of 940 abstracts and publication titles, 230 papers were included in the further stages of the review. After the analysis of full texts of articles, 115 scientific papers were finally included in the review.

OBESITY AS A DISEASE

Obesity has become one of the major concerns for public health in recent decades. It is associated with increased morbidity and mortality. It is a strong risk factor for various disorders including coronary heart disease, type 2 diabetes mellitus, arterial hypertension, dyslipidemia, sleep apnea or different types of cancer, including colon, breast, gallbladder, endometrium, kidney and liver [18, 19, 20, 21]. Recently, there are numerous reports of obesity as a risk of severe

COVID-19 infection and increased mortality in obese individuals [22, 23, 24].

Obesity is described by the World Health Organization (WHO) as an excessive fat accumulation that may endanger health [25]. The Obesity Society in their 2018 Position Statement acknowledged obesity as a chronic disease [26]. Society recognised it as a risk factor of other disorders as well as serious and threatening condition on its own. The pathology of the disease is mainly linked with abnormal nutritional behaviour. It is correlated with a positive energy balance, in which energy intake is greater than energy expenditure, causing weight gain [27]. However, obesity could also occur as a secondary cause of genetic, hypothalamic or endocrine diseases [28, 29]. Moreover, iatrogenic obesity could also be identified, most commonly induced by medications [30].

Weight gain is promoted by positive energy balance which is caused by an increased food intake, decreased level of physical activity or both. Disturbed food consumption is a consequence of increased hunger or decreased satiety. Subcortical structures of the brain, which control appetite, are being influenced by environmental factors such as food availability, accessibility of calorie-dense products, taste, marketing, advertising of specific types of foods [31]. Although, the pathology of obesity is also linked to a certain degree of genetically determined susceptibility. Similar genetic components participate in the distribution of fat, overall body composition and visceral fat deposition after a period of excessive food consumption [32].

Adiposopathy is recognised as a basis of primary obesity. It is defined as anatomic and/or functional disturbances of adipose tissue, which results in abnormal endocrine and immune responses [33, 21]. Visceral adiposity, adipocyte hypertrophy and secretion of leptin and pro-inflammatory mediators by the adipose tissue are sustaining the state of adiposopathy. Metabolic and hormonal changes contribute to the insulin resistance that is often present in obese individuals [34, 35]. Therefore, obesity may lead to the dysregulation of the metabolic pathways. The presence of pro-inflammatory proteins could induce a low-grade systemic inflammatory state [36]. Disruption of metabolic homeostasis contributes to the development of atherosclerosis, hypertension, dyslipidemia, type 2 diabetes mellitus, hyperandrogenemia [37].

Excess lipids are stored mostly as subcutaneous adipose tissue. Visceral adipose tissue is additional storage for lipids [38]. Visceral adipose tissue has a stronger link to metabolic disturbances in obese individuals than subcutaneous adipose tissue [39]. Adipose tissue located around kidneys may lead to

increased renal compression, resulting in elevated blood pressure. Therefore, hypertension is often observed in obese patients [40]. An increase of pharyngeal soft tissues may disturb the function of the airways leading to obstructive sleep apnea [41]. Elevated intraabdominal pressure caused by the visceral adipose tissue has a harmful effect on the oesophagus, causing gastroesophageal reflux disease or *Barrett's* oesophagus [42]. Excessive weight also puts a mechanical load on joints, hence increased risk of osteoarthritis in obese individuals [43].

The most common method of diagnosing obesity is body mass index (BMI). The index helps to determine healthy or abnormal body weight, taking into account the height and weight of an individual. For most adults, BMI between 18.5 kg/m² and 24.9 kg/m² is considered to be a healthy weight. BMI >25 kg/m² is categorised as overweight and BMI >30 kg/m² as obese [25]. Although BMI is a useful tool in public health, it has its limitations. As an indirect measure, it relies only on height and weight and it does not include the percentage of body fat of body composition. BMI does not include changes that occur during ageing when the proportion between fat mass and free fat mass increases [44, 45, 46, 47].

As the world prevalence of obesity is increasing every year, it requires urgent attention and action. Therefore, the proper diagnosis and treatment of obesity are key in reducing the risk of numerous comorbidities and premature death [48].

TREATMENT OF OBESITY

When prevention of obesity fails, treatment is needed. Several treatment strategies might help lose weight and reduce the risk of health consequences of obesity. The most common strategies of treating obesity include dietary modification, increased physical activity, pharmacotherapy and in some cases surgical procedures. European Guidelines point out that the aim for obesity management should not be focused only on weight (and therefore BMI) reduction. Modifications in body composition, as well as waist circumference, must be targeted when dealing with obesity. The main focus should be on maintaining the current level of fat-free mass with a simultaneous decrease in fat mass. Moreover, the treatment aims should include also improvement in the quality of life and general well-being of obese individuals [49].

Dietary modification

British National Institute for Health and Care Excellence (NICE) in their clinical guidelines clearly indicate that the diet modifications should be acknowledged food preferences, health status, lifestyle. Individual approach to diet and calorie

reduction is emphasised. Nutritionally unbalanced and restrictive diets are not recommended as they are not effective and could pose a health threat [50]. A weight-loss diet must provide less energy than is required for daily maintenance. Guidelines published by the American College of Cardiology, American Heart Association and The Obesity Society recommend an energy deficit of 500 to 750 kcal/day and an average loss of 0.5 to 0.75 kg/week [51]. Weight loss goals should be manageable and realistic, hence 5–7% of body weight within 6 months is considered achievable [52]. Very low-calorie diets (800 kcal/day or less) are not recommended as a typical weight loss strategy [50]. They should be employed as a part of a complex weight management strategy and clinically justified, usually before surgical procedures [53]. According to the American Association of Clinical Endocrinologists and American College of Endocrinology (AAACE/ACE), total energy intake is the main component of every weight-loss intervention. In their Clinical Practice Guidelines for Medical Care of Patients with Obesity is been acknowledged that the macronutrient composition of the patient's diet is not an important factor. However, it is believed that in some cases, modifying macronutrient compositions could be useful. That could include overall adherence to the diet, the level of satiety, metabolic profile or other clinical outcomes and risk factors [54].

In addition to reducing energy, some dietary patterns seem to offer other health benefits apart from weight loss. American Heart Association reviewed that a balanced, weight loss diet should focus on non-processed foods like vegetables (excluding potatoes), fruits, nuts, seeds, legumes, whole grains, lean dairy and vegetable oil. The diet should limit the amount of processed or red meat, refined grains, salt and added sugars. Healthy weight-loss diets are high in fiber and micronutrients but low in glycemic index and saturated fat content [55]. The diet content is important for health reasons; however, the specific distribution of macronutrients seems to be irrelevant in weight loss. A meta-analysis including 48 randomized trials and 7286 overweight or obese individuals was designed to determine weight loss outcomes based on the macronutrient composition of popular diets [56]. Significant weight loss was achieved both with low-fat and low-carbohydrate diets. The difference between weight loss was not significant. The author suggests that any diet would be a successful weight loss diet if only there was an individually calculated calorie reduction.

Physical activity

Physical activity is a key component of a healthy lifestyle. WHO general recommendations for the adult population advise at least 150 minutes of moderate-

intensity or at least 75 minutes of vigorous-intensity physical activity during the week [57]. AAACE/ACE also endorse an increase in nonexercised and active leisure activity as a manner of reduction of sedentary behaviour [54]. However, current physical fitness and ability as well as a general condition should be taken into consideration. Obese individuals should gradually increase their amount of physical activity [50]. Sometimes, the involvement of a physiologist or other certified professional should be taken into consideration as a part of an individualised training plan [54]. A randomized trial among 439 overweight and obese women determined that diet and exercise interventions individually affected weight loss [58]. However, the most significant effects were observed when the dietary modification and physical activity were combined. Sixty per cent of participants achieved $\geq 10\%$ weight loss at 1 year. Apart from the weight loss itself, regular physical activity could reduce blood pressure, lipid concentrations or improve glycemic control [59].

Pharmacotherapy

NICE guidelines recommend that pharmacological intervention should be considered if dietary, exercise and lifestyle approaches have been evaluated [50]. European Association for the Study of Obesity recommended drug treatment of obesity for people with a BMI ≥ 30 kg/m² or a BMI ≥ 27 kg/m² with an obesity-related disease [60]. Medications should be introduced to obesity management when there is a history of failed, not clinically meaningful weight loss ($>5\%$ of total body weight) and to sustain lost weight [61]. Three medications have been approved in the European Union: Orlistat, Liraglutide and Naltrexone SR/ bupropion SR [62]. Orlistat is a lipase inhibitor that reduces dietary fat uptake in the small intestine by about 30%. On average about 3.8 kg above placebo weight reduction was observed during clinical trials [62]. The common side effects of the medication are intestinal disturbances like fatty stool, diarrhea, increased defecation and discomfort [63]. Liraglutide is one of glucagon-like peptide-1 (GLP-1) receptor agonists. A randomized, controlled trial of liraglutide in weight management was associated with decreased body weight [64]. 3.0 mg Liraglutide injections along with diet and exercises resulted in at least 5% loss of total body weight in 63.2% of participants. Meanwhile, only 27.1% of individuals from the placebo group lost 5% or more of their total body weight. However, the main drawbacks of the medication are the price and form of administration [63]. Moreover, many clinical studies show that other GLP-1 receptor agonists therapy results in glycosylated hemoglobin (HbA1c) level reduction and weight loss. Also, they may contribute to the decrease of blood pressure [65].

In the United States, there are currently five GLP-1 receptor agonists available: exenatide, liraglutide, albiglutide, dulaglutide and lixisenatide [66]. A recent meta-analysis included nine studies of GLP-1 agonists therapy (exenatide or liraglutide) in children with type 2 diabetes and obesity. Compared to placebo, GLP-1 agonist intervention reduced HbA1c by 0.30%. The most noticeable effect was observed in prediabetic children. Also, the GLP-1 agonists intervention caused a 2,74 kg weight decrease. In the study, GLP-1 agonists were described as efficacious in treating children with obesity and/or type 2 diabetes and the effect sizes were comparable with those observed in adult-focused studies [67].

Bupropion/naltrexon is a combination of a mild reuptake inhibitor of dopamine and norepinephrine and an opioid antagonist. The drug is responsible for reducing appetite and food cravings. It could possibly elevate the blood pressure, so it is not recommended for patients with hypertension [68].

Surgical procedures

Surgical treatment of obesity has been recently growing in popularity as a treatment option for severe obesity. NICE inclusion criteria for bariatric surgery are: BMI of 40 kg/m² or more or between 35-40 kg/m² and other significant disease that could be improved if a person lost weight [50]. Main bariatric procedures are adjustable gastric banding, sleeve gastrectomy and Roux-en-Y gastric bypass [63]. Obese patients who consider undergoing bariatric surgery should be fully aware and informed about possible risks and benefits. Data from 2020 indicates, that the perioperative mortality rates range from 0.03% to 0.2%, which has significantly improved since the beginning of the century [69].

BEHAVIORAL INTERVENTIONS

Concept of motivational dialogue and lifestyle change

Recently, studies taking into account the psychological aspect are an increasingly common response to the problem of obesity. Improving self-efficacy and working on psychological changes in eating habits are essential to successfully and permanently rid oneself of obesity [70, 71, 72, 73]. It has been suggested that a combination of motivational dialogue, a behavior change technique, along with cognitive behavioral therapy can lead to improved eating behaviors [74, 75]. In a randomized controlled trial involving 816 male blue-collar and white-collar workers in the construction industry with an increased risk of cardiovascular disease (CVD), a lifestyle change intervention was introduced. The intervention consisted of individual counseling using motivational

interviewing techniques and lasted 6 months. During this time, study participants participated 3 times in a 45-60 minute conversation with a physician during an appointment and 4 times for 15-30 minutes each through a telephone conversation. During the interview, the interviewer used motivational interviewing (MI) techniques such as asking open-ended questions, attentive listening, or raising causality in the subject. Participants in the control group received usual care, consisting of brief oral or written information from an occupational physician about their risk profile, based on the results of periodic screening tests. Both study groups had an access to the same educational materials on physical activity, healthy eating, and cardiovascular disease. After 6 months, a positive effect was noted in terms of healthy snack choices and increased fruit consumption in the intervention group. In addition, this group had significantly less smoking problem within 6 months after the intervention. However, in the longer term, i.e., 1 year after the intervention, this effect was not maintained and there was no longer a difference in adherence to beneficial lifestyle modifications between the groups [76].

The researchers had a different observation when they wanted to see if a healthy lifestyle motivation program had a better impact than standard care after cardiac rehabilitation was completed. The program was based on self-regulation principles and consisted of a motivational interview, 7 group sessions, and homework assignments. The lifestyle intervention program was associated with a 12% reduction in cardiac hospitalizations in the intervention group at 15 months after the study than in the group without the intervention. At the same time, the researchers found that the effect of lifestyle change was diminishing over time, which may suggest that this type of intervention should take place on a continuous or cyclical basis to influence subjects' behavior throughout their lifespan [77]. Similar findings were made by Martens et. al. who in their study observed a positive effect of MI on increasing physical activity in students reporting low levels of physical activity (PAL). However, they also emphasize that this type of motivation may be short-lived [78].

The concept of self-control

In interventions exploring the concept of self-control, the subjects are asked to self-control their eating behaviors. Self-control can increase subjects' awareness of health-promoting behaviors. However, it is also worth mentioning that studies of this type are difficult to evaluate and monitor, because their results are usually reported by the subjects themselves on a declarative basis [79]. A different approach was shown by the researchers Wang et al. who in their study wanted to see which strategy was better in terms

of achieving a reduction in excess body weight. They compared the effectiveness of self-control of subjects who self-reported their weight loss results during a 12-month dietary intervention (PR) and self-control using automated report reminders through personal digital assistants (PDAs). Both groups followed a similar dietary intervention, which was based on an energy deficit diet at the same level. The study found that both PR and PDA were significant factors in weight loss. Additionally, the use of automatic reminders that the PDA group had access to, increased the effectiveness of weight loss during the intervention and adherence to the recommended level of physical activity. In their conclusions, the authors also point to the need for the development of further technologies to aid in the monitoring of diet and physical activity in weight loss, such as phone apps and smart watch devices [80]. Similar observations were noted in numerous studies analyzing the relationship between self-control and successful weight loss [81, 82, 83, 84, 85, 86].

Setting goals

The first premise of working with a patient during a dietary intervention is to set a goal to work toward. The goal should be time-bound, measurable, attainable, and challenging. Additionally, and most importantly in a dietetic intervention, goal achievement should be linked to the development of a new eating habit and lifestyle change [87]. Tools to monitor adherence to goals are an extremely important part of dietetic collaboration and the evaluation of goal achievement and setting new goals is the essence of the dietitian's work, because goal achievement leads to changes in eating habits [88]. It is believed that setting an appropriate strategy is extremely important in effective dietetic collaboration, and goal setting itself is individual and requires good knowledge of the patient. However, it is emphasized that the goal-setting strategy is one of the most important behavioral strategies a nutrition professional can use [89]. Behavioral interventions aimed at weight loss are themselves effective and an appropriate tool to combat the problem of obesity [90].

ONLINE INTERVENTIONS

With the rapid development of web-based applications and the online model of healthcare delivery, consultations in the field of dietetics are also undergoing a restructuring [91]. The COVID-19 pandemic, through which some dietetic brokering services have moved to the online sector, has also had a not insignificant impact [92]. Moreover, recent studies conducted during the COVID-19 pandemic in Poland as well as in other countries indicate that

during the lockdown period body weight increased in the study groups [93, 94, 95]. Taking this into account, it seems that online nutritional counseling is a very good solution.

Telemedicine is the delivery of healthcare services using information and communication technology when the healthcare professional and the patient are not in the same location. Telemedicine uses the transmission of data, medical information, necessary for prevention, treatment, and health monitoring of the patient [96].

Based on research and practice, dietetic services are beginning to shift from in-office consultations to a form of online consultation using mobile apps and websites. To counter it, the global problem of obesity development needs interventions that can be implemented on a large scale and will be easily accessible to the patient [97]. In recent years, there has been an increased trend of implementing web-based technologies for disease detection, prevention, treatment, and health promotion [98]. E-health, or electronic health, is defined as "the use of information and communication technologies, particularly the Internet, to improve health and health care" [99].

With web-based technology, dietitians can effectively collect patient data, develop nutrition plans, communicate with patients, and monitor the effects of dietary intervention [100, 101, 102]. Coordinating this information in a single platform promotes patient nutrition awareness, provides rapid feedback in the patient-dietitian relationship, or enables dietary changes to be made based on individualized recommendations from a professional [103, 104].

The study by Chung et al. evaluated the effectiveness of online dietary consultation (teledietetics) versus inpatient services in reducing weight over 24 weeks and the costs associated with weight loss. Fifty subjects aged 20 to 50 years with a BMI greater than or equal to 23 kg/m² participated in the study. Each group consisted of 25 participants. One group received inpatient dietary counseling and the other group received online dietary counseling. All participants received the intervention for 12 weeks and follow-up for another 12 weeks. The inpatient consultation group received 1- 1.5 hours of dietary counseling once a week and recorded their food intake in a food diary. In contrast, the online consultation group received a total of 6 hours of nutrition training, individualized feedback from the dietitian, and recorded their food intake on an online platform. After 6 weeks of intervention, body weight and body fat were found in the inpatient consultation group. At week 12, however, weight and body fat reduction were significantly higher in the online consultation group, 5.1 kg vs. 4.5 kg and 3.97 kg vs. 2.38 kg, respectively. However, the differences were not statistically significant. At week

24 of the study, a statistically significant difference was noted between the groups in favor of online counseling. In terms of costs of the two forms of nutrition counseling, it was observed that the direct costs of 1% weight loss and 1% body fat loss were \$28.24 for inpatient consultation and \$17.09 for online consultation. This indicates that online nutrition counseling is more cost-effective and more effective in the long run than inpatient counseling [105].

iDiet WL (*iDiet weight loss*) is a commercial weight loss program. Data from 644 individuals enrolled in an 11-week group program focusing on weight loss were analyzed. The program was delivered through weekly hour-long group meetings that included nutrition education, weight management, support, and discussion. Participants were able to communicate with the participants and leader and report their measurements on a website. Data for analysis were collected from programs conducted in the workplace, individually created groups, or online video conferences. The mean initial BMI was 32.4 ± 7.1 kg/m². Results indicated that videoconference participants, older adults, and self-registrants to groups were more likely to report their results. However, after 11 weeks, % weight loss was not associated with initial BMI, gender, or videoconferencing when comparing to the inpatient groups. After 11 weeks, the average weight loss was 7.4 kg, with 74% of participants achieving a 5% weight loss. Study participants had significant clinical weight loss, which encourages wider implementation of the iDiet program both inpatient and online [106].

The effectiveness of online health and nutrition interventions in older adults was examined by *Batsis et al.* [107] in an observational study. The primary objective of the study was to assess the acceptability and feasibility of web-based intervention methods for weight management in older adults with obesity. The study included 142 subjects equal to or greater than 65 years of age residing in a community-based facility. The duration of the study was 6 months (October 2018 to May 2019). Study participants had a BMI equal to or greater than 30 kg/m². The intervention consisted of weekly video consultations with a dietitian, consisting of behavioral therapy and dietary calorie restriction. Additionally, participants had twice-weekly exercise classes with physiotherapists, which were also conducted online (video consultations). Participants in the study used a "Fitbit Altra HR" device to monitor activity. After 6 months of intervention, a mean weight loss of 4.6 +/- 3.5 kg was observed. In terms of fitness, improvements were noted, among others, in participants' sitting and standing up. The results indicate that an online technology-based intervention for health improvement (weight loss) is acceptable and possible for older adults with obesity. It addresses

both effectiveness in weight loss and improvement in physical performance [107]. The effectiveness and feasibility of dietary counseling with the help of apps was also tested by Swiss researchers. With the technology developed by Ovia company for dietitians, serving advice to overweight and obese patients, a study was conducted with 36 women and 7 men. After the entire intervention period (12 weeks), statistically significant differences were noted in median weight change, BMI, waist circumference. There were also changes in dietary habits including an increase in the frequency of vegetable, fruit and breakfast intake and a decrease in the frequency of consumption of sweets, fat and alcohol [108].

A systematic review of randomized controlled trials was conducted on the effectiveness of online interventions for the prevention and treatment of overweight and obesity in adults. Eighty-four studies were included in the analysis, with 183 intervention groups, 76% (n=139) of which included an online intervention. Online interventions were delivered via the Internet, using email, monitoring devices, mobile apps, software programs, personal digital assistants, and podcasts. Sixty-one studies were designed to reduce weight, 10 to maintain current weight, and 8 were designed to prevent weight gain, while 5 were designed to lose and maintain weight. Meta-analyses indicate significantly greater weight loss (kg) in teleconsultation interventions aimed at weight reduction compared with control groups where counseling was provided in a face-to-face manner. The data collected support the effectiveness of using online interventions as a treatment option for obesity. However, there is still insufficient evidence for their effectiveness in maintaining reduced body weight and preventing weight gain [109].

Researchers came to similar findings in another meta-analysis, confirming the effectiveness of online nutritional counseling in decreasing BMI in obese adults with hypertension and/or type 2 diabetes [110]. They considered 25 randomized control trials with intervention lengths ranging from 9 weeks to 2 years. They found significant differences in BMI changes between the intervention groups using online counseling and the control groups. However, the researchers suggest that the telemedicine intervention should last longer than six months and note that it is important to observe the patient after the intervention ends.

A meta-analysis by *Beleigoli et al.* [111] also examined the effectiveness of online versus non-technology health interventions on weight loss and lifestyle change in overweight and obese individuals. Eleven studies were included in the analysis and showed that weight and BMI changes differed between online and offline counseling. Online interventions

led to greater short-term weight reduction, but not long-term weight reduction. However, heterogeneity between groups was a problem in the evaluation. It was also indicated that the commitment is one of the problems with online interventions [111].

Similar findings were reached recently in 2021 by researchers evaluating the effectiveness of weight loss in an online intervention in various countries - the United States, the United Kingdom and Ireland, Canada, Australia, and New Zealand. After 16 weeks, the study participants' body weight dropped between 3% and 3.7% in all regions. The researchers also found preliminary support for the premise that online nutrition interventions developed in one country can be applied globally across countries, despite differences in attitudes toward eating and physical activity [112].

An interesting study was conducted in France. Its objectives were to evaluate the impact of a nationwide lockdown (during the COVID-19 pandemic) in France on weight loss and changes in body composition in individuals participating in a weight loss program, and to assess the impact of an online consultation on adherence to a program focusing on weight loss. This was a prospective multicenter cohort study involving individuals participating in the program over a period of two to six months. 1550 individuals completed the remote weight loss program. The median weight loss was 4.4 kg in those with online services and 1.4 kg in those without consultation, a difference was statistically significant. The study demonstrates the effectiveness of the online intervention in a nationwide lockdown setting [113].

Social support also plays an important role in the effectiveness of excessive weight loss. Simpson et al. [114] examined the acceptability of an intervention based on the use of an app, an online network, and social support in obese adults in an effort to lose weight. The study included 109 individuals with BMI ≥ 30 kg/m², 73 individuals in the intervention group and 36 individuals in the control group. The focus was on assessing 3 main parameters - BMI, diet and physical activity. The intervention group had access to the HelpMeDoIt! app and website for 12 months. The website provided evidence-based information on weight loss, goal setting and monitoring, and advice on using social support from relatives. In contrast, the app gave participants the ability to set weight loss goals, monitor progress, and invite people to support them. The control group received a healthy lifestyle pamphlet. All participants were able to further access other available sources of knowledge about lifestyle changes or support. Data after the 12-month intervention indicated that HelpMeDoIt promoted social support to weight loss. Support and progress monitoring were key elements for study participants. 61% of goals created by participants in

the app were met. The average percentage weight loss for those in the intervention group was -3.2% and for the control group was -2.3%. The study indicates that a novel social support intervention, in the form of an app and website, can promote the pursuit of healthy weight and is feasible and acceptable to people [114]. Other researchers testing the effectiveness of online health interventions on health behaviors have reached similar conclusions. They noted the great potential of online interventions for engagement and achievement of stated goals. Developing and evaluating online interventions poses new challenges and new versions of old challenges that require improved and perhaps entirely new research and evaluation methods. Future health economic analyses must recognize and model the complex and potentially far-reaching costs and benefits of digital interventions [115].

CONCLUSIONS

Data from the aforementioned studies suggest that the effectiveness of online interventions for weight control is high enough to be worthwhile for both nutrition education and weight reduction and/or maintenance. Limitations associated with inpatient nutrition interventions such as time consuming, costs can be overcome by introducing the possibility for patients to benefit from online interventions with similar effectiveness. Online nutrition consultation also has the advantage of wide access to the public. Both forms of intervention should be considered for health-promoting lifestyle modification of patients.

Data availability

No data were used to support this review paper.

Conflict of interest

The authors declare that they have no conflicts of interest.

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REFERENCES

1. WHO. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight> 2021.
2. Iversen, T. & Soskice, D. *Democracy and prosperity: Reinventing capitalism through a turbulent century* (Princeton University Press, 2019).
3. Schwartz MW, Seeley RJ, Zeltser LM, Drewnowski A, Ravussin E, Redman LM, Leibel RL. *Obesity Pathogenesis: An Endocrine Society Scientific Statement*. *Endocr Rev.* 2017 Aug 1;38(4):267-296.
4. Darmon, N., Drewnowski, A. Does social class predict diet quality? *Am. J. Clin. Nutr.* 2008;87:1107–1117.

5. Kim TJ, von dem Knesebeck O. Income and obesity: what is the direction of the relationship? A systematic review and meta-analysis. *BMJ Open*. 2018 Jan5;8(1):e019862.
6. Hill B, Bergmeier H, Incollingo Rodriguez AC, Barlow FK, Chung A, Ramachandran D, Savaglio M, Skouteris H.: Weight stigma and obesity-related policies: A systematic review of the state of the literature. *Obes Rev*. 2021 Sep 9. e13333.
7. Chin SH, Kahathuduwa CN, Binks M.: Physical activity and obesity: what we know and what we need to know. *Obes Rev*. 2016 Dec;17(12):1226-1244.
8. Jakicic JM, Davis KK.: Obesity and physical activity. *Psychiatr Clin North Am*. 2011 Dec;34(4):829-40..
9. Ho SS, Dhaliwal SS, Hills AP, Pal S.: The effect of 12 weeks of aerobic, resistance or combination exercise training on cardiovascular risk factors in the overweight and obese in a randomized trial. *BMC Public Health*. 2012 Aug 28;12:704.
10. Hopkins M, Blundell J, Halford J, King N, Finlayson G.: The Regulation of Food Intake in Humans. 2016 Mar 30. Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000-. PMID: 25905169.
11. Schlesinger S, Neuenschwander M, Schwedhelm C, et al.: Food Groups and Risk of Overweight, Obesity, and Weight Gain: A Systematic Review and Dose-Response Meta-Analysis of Prospective Studies. *Adv Nutr*. 2019;10(2):205-218.
12. Bjorntorp, P.: Do stress reactions cause abdominal obesity and comorbidities? *Obes. Rev*. 2001;2:73–86.
13. Kim, D., Subramanian, S. V., Gortmaker, S. L. & Kawachi, I.: US state- and county-level social capital in relation to obesity and physical inactivity: a multilevel, multivariable analysis. *Soc. Sci. Med*. 2006;63:1045–1059.
14. Yang J, Hu J, Zhu C.: Obesity aggravates COVID-19: A systematic review and meta-analysis. *J Med Virol*. 2021 Jan;93(1):257-261.
15. Dobrowolski H, Włodarek D.: Body Mass, Physical Activity and Eating Habits Changes during the First COVID-19 Pandemic Lockdown in Poland. *Int J Environ Res Publ Health*. 2021;18(11):5682.
16. Kolotkin RL, Andersen JR.: A systematic review of reviews: exploring the relationship between obesity, weight loss and health-related quality of life. *Clin Obes*. 2017 Oct;7(5):273-289.
17. Stevens GA, Singh GM, Lu Y, Danaei G, Lin JK, Finucane MM, Bahalim AN, McIntire RK, Gutierrez HR, Cowan M, et al.: National, regional, and global trends in adult overweight and obesity prevalences. *Popul Health Metrics*. 2012;10:22.
18. Vucenik I, Stains J.P.: Obesity and cancer risk: evidence, mechanisms, and recommendations, *Annals of the New York Academy of Sciences*, 2012 1271(1):37–43.
19. Chrostowska M., Szyndler A., Hoffmann M., Narkiewicz K.: Impact of obesity on cardiovascular health. *Best Pract. Res. Clin. Endocrinol. Metab*. 2013;27(2):147–56.
20. De Pergola G., Silvestris F.: Obesity as a major risk factor for cancer. *J. Obes*. 2013;291546.
21. De Lorenzo A., Gratteri S., Gualtieri P., Cammarano A., Bertucci P., Di Renzo L.: Why primary obesity is a disease? *J Transl Med.*, 2019;17(1):169.
22. Dietz W., Santos-Burgoa C.: Obesity and its implications for covid-19 mortality. *Obesity*, 2020;28(6):1005–1005.
23. Korakas E., Ikonomidis I., Kousathana F., Balampanis K., Kountouri A., Raptis A., et al.: Obesity and COVID-19: immune and metabolic derangement as a possible link to adverse clinical outcomes, *American Journal of Physiology-Endocrinology and Metabolism*, 2020;319(1):105–09.
24. Sattar N., McInnes I.B., McMurray J.J.V.: Obesity is a risk factor for severe covid-19 infection: multiple potential mechanisms. *Circulation*, 2020;142(1):4–6.
25. WHO. Obesity and overweight. 2021 [cited 2021 Sep 22]. Available from: <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
26. Jastreboff A.M., Kotz C.M., Kahan S., Kelly A.S., Heymsfield S.B.: Obesity as a disease: the obesity society 2018 position statement. *Obesity*, 2019;27(1):7–9.
27. O'Hill J.O., Peters J.C.: The importance of energy balance. *Eur Endocrinol*, 2010; 9(2):111.
28. Wright S.M., Aronne L.J.: Causes of obesity, *Abdom Radiol.*, 2012 37(5):730–732.
29. van der Valk E.S., Akker E.L.T, Savas M., Kleinendorst L., Visser J.A., Van Haelst M.M., et al.: A comprehensive diagnostic approach to detect underlying causes of obesity in adults. *Obesity Reviews*, 2019;20(6):795–804.
30. Kumar R.B., Aronne L.J.: Iatrogenic obesity. *Endocrinol. Metab. Clin. North Am*. 2020;49(2):265–73.
31. Abdelaal M., Roux C.W., Docherty N.G.: Morbidity and mortality associated with obesity. *Ann. Transl. Med*. 2017;5(7):8.
32. Poveda A., Koivula R.W., Ahmad S., Barroso I., Hallmans G., Johansson I., et al.: Innate biology versus lifestyle behaviour in the aetiology of obesity and type 2 diabetes: the GLACIER Study, *Diabetologia*, 2016;59(3):462–471.
33. Bays H.: Central obesity as a clinical marker of adiposopathy; increased visceral adiposity as a surrogate marker for global fat dysfunction, *Curr. Opin. Endocrinol. Diabetes Obes*. 2014;21(5):345–351.
34. Cao H.: Adipocytokines in obesity and metabolic disease. *J. Endocrinol*. 2014;220(2):47–59.
35. Grant R.W., Dixit V.D.: Adipose tissue as an immunological organ: adipose tissue as an immunological organ. *Obesity*, (2015) 23(3):512–518.
36. Tchkonja T, Thomou T, Zhu Y, Karagiannides I, Pothoulakis C, Jensen M.D., et al.: Mechanisms and metabolic implications of regional differences among fat depots. *Cell Metab*. 2013;17(5):644–656.
37. Longo M., Zatterale F., Naderi J., Parrillo L., Formisano P., Raciti G.A., et al.: Adipose tissue dysfunction as determinant of obesity-associated

- metabolic complications, *Int. J. Mol. Sci.* 2019;20(9): 2358.
38. Alexopoulos N., Katritsis D., Raggi P.: Visceral adipose tissue as a source of inflammation and promoter of atherosclerosis. *Atherosclerosis* 2014;233(1):104–112.
 39. Liu L., Feng J., Zhang G., Yuan X., Li F., Yang T., et al.: Visceral adipose tissue is more strongly associated with insulin resistance than subcutaneous adipose tissue in Chinese subjects with pre-diabetes. *Curr Med Res Opin.* 2018;34(1):123–129.
 40. Hall J., Juncos L., Wang Z., Hall M., do Carmo J., da Silva A.: Obesity, hypertension, and chronic kidney disease, *Int. J. Nephrol. Renovasc. Dis.* 2014;75-88; DOI: 10.2147/IJNRD.S39739
 41. Heymsfield S.B., Wadden T.A.: Mechanisms, pathophysiology, and management of obesity, *N. Engl. J. Med.*, 2017;376(3):254–266.
 42. El-Serag H.B., Hashmi A., Garcia J., Richardson P., Alsarraj A., Fitzgerald S., et al.: Visceral abdominal obesity measured by CT scan is associated with an increased risk of Barrett's oesophagus: a case-control study, *Gut*, 2014;63(2):220-229.
 43. King L.K., March L., Anandacoomarasamy A.: Obesity & osteoarthritis, *Indian J. Med. Res.* 2013;138(2):185-193.
 44. Gosse M.A.: How accurate is self-reported BMI?: How accurate is self-reported BMI?, *Nutrition Bulletin*, (2014) 39(1):105–114.
 45. Müller M.J., Braun W., Enderle J., Bopsy-Westphal A.: Beyond BMI: conceptual issues related to overweight and obese patients, *Obes. Facts*, (2016) 9(3):193–205.
 46. Gutin I.: In BMI we trust: reframing the body mass index as a measure of health. *Soc. Theory Health*, 2018;16(3):256–271.
 47. Müller M.J., Geisler C.: Defining obesity as a disease, *Eur. J. Clin. Nutr.* 2017;71(11):1256–1258.
 48. Chooi Y.C., Ding C., Magkos F.: The epidemiology of obesity. *Metabolism*, 2019;92:6–10.
 49. Yumuk V., Tsigos C., Fried M., Schindler K., Busetto L., Micic D., Toplak H.: European Guidelines for Obesity Management in Adults, *Obes. Facts*, 2015;8:402-424.
 50. National Clinical Guideline Centre (UK). Obesity: identification, assessment and management of overweight and obesity in children, young people and adults: partial update of cg43 [Internet]. London: National Institute for Health and Care Excellence (UK); 2014 [cited 2021 Sep 24]. (National Institute for Health and Clinical Excellence: Guidance). <http://www.ncbi.nlm.nih.gov/books/NBK264165/>
 51. Jensen M.D., Ryan D.H., Apovian C.M., Ard J.D., Comuzzie AG, Donato KA, et al. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults. *J. Am. Coll. Cardiol.* 2014;63(25): 2985–3023.
 52. Fock K.M., Khoo J.: Diet and exercise in management of obesity and overweight: Diet and exercise for weight management, *J. Gastroenterol. Hepatol.* 2013;28:59–63.
 53. Faria S.L., Faria O.P., Cardeal M. A., Ito M.K.: Effects of a very low-calorie diet in the preoperative stage of bariatric surgery: a randomized trial. *Surg Obes Relat Dis.* 2015;11(1):230–237.
 54. AACE/ACE, American Association of Clinical Endocrinologists and American College of Endocrinology Comprehensive Clinical Practice Guidelines for Medical Care of Patients with Obesity, *Endocr. Pract.*, 2016; 22, Suppl 3.
 55. Mozaffarian D.: Dietary and policy priorities for cardiovascular disease, diabetes, and obesity: a comprehensive review, *Circulation*, 2016;133(2):187–225.
 56. Johnston B., Kanters S., Bandayrel K., Wu P., Naji F., Siemieniuk R.A., et al., Comparison of weight loss among named diet programs in overweight and obese adults: a meta-analysis, *JAMA*, 2014;312(9):923.
 57. WHO. Physical activity. 2020 [cited 2021 Sep 22]. Available from: <https://www.who.int/news-room/fact-sheets/detail/physical-activity>
 58. Foster-Schubert K.E., Alfano C.M., Duggan C.R., Xiao L., Campbell K.L., Kong A., et al.: Effect of diet and exercise, alone or combined, on weight and body composition in overweight-to-obese postmenopausal women, *Obesity*, 2012;20(8):1628–1638.
 59. Warburton D.E.R., Bredin S.S.D.: Health benefits of physical activity: a systematic review of current systematic reviews, *Curr. Opin. Cardiol.* 2017;32(5):541–56.
 60. Yumuk V., Frühbeck G., Oppert J.M., Woodward E., Toplak H.: An EASO position statement on multidisciplinary obesity management in adults. *Obes. Facts*, 2014;7(2):96–101.
 61. Alamuddin N., Bakizada Z., Wadden T.A., Management of obesity. *J. Clin. Oncol.* 2016;34(35):4295–4305.
 62. May M., Schindler C., Engeli S.: Modern pharmacological treatment of obese patients. *Therapeutic Advances in Endocrinology*, (2020) 11.
 63. Bray G.A., Frühbeck G., Ryan D.H., Wilding J.P.H.: Management of obesity, *The Lancet*, 2016; 387(10031):1947–1956.
 64. Pi-Sunyer X., Astrup A., Fujioka K., Greenway F., Halpern A., Krempf M., et al., A randomized, controlled trial of 3.0 mg of liraglutide in weight management, *N. Engl. J. Med.* 2015;373(1):11–22.
 65. Babenko A.Y., Savitskaya D.A., Kononova Y.A., Trofimova A.Y., Simanenkova A.V., Vasilyeva E.Y., Shlyakhto E.V.: Predictors of Effectiveness of Glucagon-Like Peptide-1 Receptor Agonist Therapy in Patients with Type 2 Diabetes and Obesity. *J Diabet Res*, 2019;1-10.
 66. Tran K.L., Park Y.I., Pandya S., Muliylil N.J., Jensen B.D., Huynh K., Nguyen Q.T., Overview of Glucagon-Like Peptide-1 Receptor Agonists for the Treatment of Patients with Type 2 Diabetes, *Am. Health. Drug. Benefits.*2017;10(4): 178-188.
 67. Chadda K.R., Cheng T.S., Ong K.K.. GLP-1 agonists for obesity and type 2 diabetes in children: Systematic review and meta-analysis. *Obesity Reviews*, (2020).
 68. Billes S.K., Sinnayah P., Cowley M.A.: Naltrexone/bupropion for obesity: An investigational combination

- pharmacotherapy for weight loss. *Pharmacol. Res.* 2014;84:1–11.
69. *Arterburn D.E., Telem D.A., Kushner R.F., Courcoulas A.P.*: Benefits and risks of bariatric surgery in adults: a review, *JAMA* 2020;324(9):879.
70. *Looney SM, Raynor HA.*: Behavioral lifestyle intervention in the treatment of obesity. *Health Serv Insights.* 2013;6:15–31.
71. *Armstrong MJ, Mottershead TA, Ronksley PE, Sigal RJ, Campbell TS, Hemmelgarn BR.*: Motivational interviewing to improve weight loss in overweight and/or obese patients: a systematic review and meta-analysis of randomized controlled trials. *Obes Rev.* 2011;12(9):709–723.
72. *Donnelly JE, Blair SN, Jakicic JM, Manore MM, Rankin JW, Smith BK.*: American College of Sports Medicine position stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Med Sci Sports Exerc.* 2009;41(2):459–471.
73. *Lundahl B, Burke BL.*: The effectiveness and applicability of motivational interviewing: a practice-friendly review of four meta-analyses. *J Clin Psychol.* 2009;65(11):1232–1245.
74. *Lundahl B, Burke BL.*: The effectiveness and applicability of motivational interviewing: a practice-friendly review of four meta-analyses. *J Clin Psychol.* 2009;65(11):1232–1245.
75. *Heckman CJ, Egleston BL, Hofmann MT.* Efficacy of motivational interviewing for smoking cessation: a systematic review and meta-analysis. *Tob Control.* 2010;19(5):410–416.
76. *Groeneveld IF, Proper KI, van der Beek AJ, Hildebrandt VH, van Mechelen W.*: Short and long term effects of a lifestyle intervention for construction workers at risk for cardiovascular disease: a randomized controlled trial. *BMC Public Health.* 2011 Oct 31;11:836.
77. *Janssen V, De Gucht V, van Exel H, Maes S.*: A self-regulation lifestyle program for post-cardiac rehabilitation patients has long-term effects on exercise adherence. *J Behav Med.* 2014 Apr;37(2):308–21.
78. *Martens MP, Buscemi J, Smith AE, Murphy JG.*: The short-term efficacy of a brief motivational intervention designed to increase physical activity among college students. *J Phys Act Health.* 2012 May;9(4):525–32.
79. *Kanfer FH.*: Self-monitoring: Methodological limitations and clinical applications. *J Consult Clin Psychol* 1970;35(2):148–152.
80. *Wang J, Sereika SM, Chasens ER, Ewing LJ, Matthews JT, Burke LE.*: Effect of adherence to self-monitoring of diet and physical activity on weight loss in a technology-supported behavioral intervention. *Patient Prefer Adherence.* 2012;6:221–226.
81. *Tate DF, Wing RR, Winett RA.* Using Internet technology to deliver a behavioral weight loss program. *JAMA.* 2001;285(9):1172–1177.
82. *Tate DF, Jackvony EH, Wing RR.*: Effects of Internet behavioral counseling on weight loss in adults at risk for type 2 diabetes: A randomized trial. *JAMA.* 2003;289(14):1833–1836.
83. *Burke LE, Wang J, Sevick MA.*: Self-monitoring in weight loss: a systematic review of the literature. *J Am Diet Assoc.* 2011;111(1):92–102.
84. *Carels RA, Darby LA, Rydin S, Douglass OM, Cacciapaglia HM, O'Brien WH.*: The relationship between self-monitoring, outcome expectancies, difficulties with eating and exercise, and physical activity and weight loss treatment outcomes. *Ann Behav Med.* 2005;30(3):182–190.
85. *Conroy MB, Yang K, Elci EU, et al.*: Physical activity self-monitoring and weight loss: 6-month results of the SMART trial. *Med Sci Sports Exerc.* 2011;43(8):1568–1574.
86. *Ruffault A, Czernichow S, Hagger MS, Ferrand M, Erichot N, Carette C, Boujut E, Flahault C.*: The effects of mindfulness training on weight-loss and health-related behaviours in adults with overweight and obesity: A systematic review and meta-analysis. *Obes Res Clin Pract.* 2017 Sep-Oct;11(5 Suppl 1):90–111.
87. *Locke EA, Latham GP.*: Building a practically useful theory of goal setting and task motivation: a 35-year odyssey. *Am Psychol* 2002; 57: 705.
88. *Bovend'Eerd T, Botell RE, Wade DT.*: Writing SMART rehabilitation goals and achieving goal attainment scaling: a practical guide. *Clin Rehabil* 2009; 23: 352–361.
89. *Bandura A, Locke EA.*: Negative self-efficacy and goal effects revisited. *J Appl Psychol* 2003;88: 87–99
90. *LeBlanc EL, Patnode CD, Webber EM, Redmond N, Rushkin M, O'Connor EA.*: Behavioral and Pharmacotherapy Weight Loss Interventions to Prevent Obesity-Related Morbidity and Mortality in Adults: An Updated Systematic Review for the U.S. Preventive Services Task Force [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); 2018 Sep. Report No.: 18-05239-EF-1.
91. *Daugherty BL, Schap TE, Ettienne-Gittens R, Zhu FM, Bosch M, Delp EJ, Ebert DS, Kerr DA, Boushey CJ.*: Novel technologies for assessing dietary intake: evaluating the usability of a mobile telephone food record among adults and adolescents. *J Med Internet Res* 2012;14(2): e58.
92. *Bailly S, Fabre O, Legrand R, Pantagis L, Mendelson M, Terrail R, Tamisier R, Astrup A, Clément K, Pépin JL.*: The Impact of the COVID-19 Lockdown on Weight Loss and Body Composition in Subjects with Overweight and Obesity Participating in a Nationwide Weight-Loss Program: Impact of a Remote Consultation Follow-Up-The CO-RNPC Study. *Nutrients.* 2021 Jun 23;13(7):2152.
93. *Stanton R, To QG, Khalesi S, Williams SL, Alley SJ, Thwaite TL, Fenning AS, Vandelanotte C.* Depression, Anxiety and Stress during COVID-19: Associations with Changes in Physical Activity, Sleep, Tobacco and Alcohol Use in Australian Adults. *Int J Environ Res Public Health.* 2020 Jun 7;17(11):4065.
94. *Bhutani S., Cooper J.A.*: Covid-19-related home confinement in adults: Weight gain risks and opportunities. *Obesity.* 2020;28: 1576–1577.

95. Di Renzo L., Gualtieri P., Pivari F., Soldati L., Attina A., Cinelli G., Leggeri C., Caparello G., Barrea L., Scerbo F., et al.: Eating habits and lifestyle changes during covid-19 lockdown: An Italian survey. *J. Transl. Med.* 2020;18:229.
96. Communication From The Commission To The European Parliament. Telemedicine assistance to patients, steady health society. 2008;689.
97. Hutchesson MJ, Gough C, Müller AM, Short CE, Whatnall MC, Ahmed M, Pearson N, Yin Z, Ashton LM, Maher C, Staiano AE, Mauch CE, DeSmet A, Vandelanotte C.: Health interventions targeting nutrition, physical activity, sedentary behavior, or obesity in adults: A scoping review of systematic reviews. *Obes Rev.* 2021 Oct;22(10):e13295.
98. World Health Organization. Global strategy on digital health 2020–2025. Switzerland: WHO; 2020.
99. Eng TR.: The eHealth landscape: a terrain map of emerging information and communication technologies in health and health care. The Robert Wood Johnson Foundation; 2001.
100. Probst YC, Tapsell LC.: Computerised dietary assessment interviews: Health professionals and patients' opinions about web communications. *Nutrition & Dietetics* 2012;69:56–63.
101. Six B, Schap T, Zhu F, et al.: Evidence-based development of a mobile telephone food record. *J Am Diet Assoc* 2010;110:74–79.
102. Beasley J, Riley W, Davis A, Singh J.: Evaluation of a PDA-based dietary assessment and intervention program: a randomized controlled trial. *J Am Coll Nutr* 2008;27:280–286.
103. Donald H, Franklin V, Greene S.: The use of mobile phones in dietary assessment in young people with type I diabetes. *J Hum Nutr Diet* 2009;22(3): 256–257.
104. Chung LMY, Chung JWY.: Tele-dietetics with food images as dietary intake records in nutrition assessment. *Telemed eHealth* 2010;16(6): 691–8.
105. Chung LM, Law QP, Fong SS, Chung JW, Yuen PP.: A cost-effectiveness analysis of teledietetics in short-, intermediate-, and long-term weight reduction. *J Telemed Telecare.* 2015 Jul;21(5):268-75.
106. Das SK, Brown C, Urban LE, O'Toole J, Gamache MMG, Weerasekara YK, Roberts SB.: Weight loss in videoconference and in-person iDiet weight loss programs in worksites and community groups. *Obesity (Silver Spring).* 2017 Jun;25(6):1033-1041.
107. Batsis JA, Petersen CL, Clark MM, Cook SB, Kotz D, Gooding TL, Roderka MN, Al-Nimr RI, Pidgeon D, Haedrich A, Wright KC, Aquila C, Mackenzie TA. Feasibility and acceptability of a technology-based, rural weight management intervention in older adults with obesity. *BMC Geriatr.* 2021 Jan 12;21(1):44.
108. Haas K, Hayoz S, Maurer-Wiesner S.: Effectiveness and Feasibility of a Remote Lifestyle Intervention by Dietitians for Overweight and Obese Adults: Pilot Study. *JMIR Mhealth Uhealth.* 2019 Apr 11;7(4):e12289.
109. Hutchesson MJ, Rollo ME, Krukowski R, Ells L, Harvey J, Morgan PJ, Callister R, Plotnikoff R, Collins CE.: eHealth interventions for the prevention and treatment of overweight and obesity in adults: a systematic review with meta-analysis. *Obes Rev.* 2015 May;16(5):376-92.
110. Huang JW, Lin YY, Wu NY.: The effectiveness of telemedicine on body mass index: A systematic review and meta-analysis. *J Telemed Telecare.* 2019 Aug;25(7):389-401.
111. Beilegoli AM, Andrade AQ, Caçado AG, Paulo MN, Diniz MFH, Ribeiro AL.: Web-Based Digital Health Interventions for Weight Loss and Lifestyle Habit Changes in Overweight and Obese Adults: Systematic Review and Meta-Analysis. *J Med Internet Res.* 2019 Jan 8;21(1):e298.
112. Yang Q, Mitchell ES, Ho AS, DeLuca L, Behr H, Michaelides A.: Cross-National Outcomes of a Digital Weight Loss Intervention in the United States, Canada, United Kingdom and Ireland, and Australia and New Zealand: A Retrospective Analysis. *Front Public Health.* 2021 Jun 10;9:604937.
113. Bailly S, Fabre O, Legrand R, Pantagis L, Mendelson M, Terrail R, Tamisier R, Astrup A, Clément K, Pépin JL.: The Impact of the COVID-19 Lockdown on Weight Loss and Body Composition in Subjects with Overweight and Obesity Participating in a Nationwide Weight-Loss Program: Impact of a Remote Consultation Follow-Up-The CO-RNPC Study. *Nutrients.* 2021 Jun 23;13(7):2152.
114. Simpson SA, Matthews L, Pugmire J, McConnachie A, McIntosh E, Coulman E, Hughes K, Kelson M, Morgan-Trimmer S, Murphy S, Utkina-Macaskill O, Moore LAR.: An app-, web- and social support-based weight loss intervention for adults with obesity: the 'HelpMeDoIt!' feasibility randomised controlled trial. Pilot Feasibility Study. 2020 Sep 19;6:133.
115. Michie S, Yardley L, West R, Patrick K, Greaves F.: Developing and Evaluating Digital Interventions to Promote Behavior Change in Health and Health Care: Recommendations Resulting From an International Workshop. *J Med Internet Res.* 2017 Jun 29;19(6):e232.

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OMICRON SUB-VARIANTS: IS THE WORLD GOING TO WITNESS ANOTHER WAVE?

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ABSTRACT

Omicron, the new 'Variant of Concern' of SARS-CoV-2, is rapidly evolving into new sub-variants or sub-lineages (BA.1, BA.2 etc.). These sub-variants have higher transmissibility, decreased vaccine effectiveness and increased risk of re-infection. As a result, many nations across the globe are reporting surge in infections which is a matter of concern. Understanding Omicron and its sub-variants is vital for development of public health policy and preventing disease transmission. The present paper throws a spotlight on the newly detected sub-variants of Omicron as reported in ongoing researches which are available only in pre-print form and also the importance of a booster dose of the vaccine. Information regarding recent research on a new nasal vaccine formulation, which may be effective against the new variants, is also highlighted in the paper.

Key words: *Omicron, sub-variants, transmission, vaccine, genome*

INTRODUCTION

'Omicron' (B.1.1.529), a recent variant of COVID-19, first detected on November 9, 2021, has been designated as 'Variant of Concern' (VOC) by World Health Organization (WHO) [12]. Since its detection, Omicron has been sequenced all over the world and appears to be responsible for driving several outbreaks of SARS-CoV-2 or causing existing outbreaks to accelerate. Recently, on the basis of computational analysis, it was divided into three sub lineages (BA.1, BA.2 and BA.3). BA.1 and BA.2 are more dominant as they have the ability to overcome the defences of even highly immune individuals and it has been reported that sub lineage BA.1 has spread to more than 130 nations [6, 7].

After several weeks of declines, reported cases of COVID-19 are once again increasing globally. Covid cases have surpassed 500 million as new infections are occurring at a rapid rate in many countries of Europe and Asia because of sub variant BA.2 [4]. The recent surges in China and record infections in Europe

are as a result of rise of BA.2. It has been called as the 'stealth variant' as it is harder to track as compared to other variants. Highest average number of new cases have been reported from South Korea with more than 1,82,000 cases being reported on daily basis. Cases are also rising in smaller South Asian countries like Thailand, Taiwan and Bhutan. China is witnessing its worst Covid outbreak since the emergence of the virus in Wuhan in 2019, with its major financial capital, Shanghai reporting more than 25000 cases per day [3]. Apart from Shanghai, 18 other provincial-level regions on the mainland saw new local COVID-19 cases. India is also witnessing sharp rise in daily cases especially in its capital city, New Delhi. Revised COVID protocols are being framed in the national capital as new infections are surging at the state and the national level due to Omicron sub-variants.

Recombinants of Omicron

As a result of genetic selection, viruses naturally evolve and are continuously changing. They have the ability to undergo minor genetic changes through

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mutation, as well as major genetic changes through recombination [14]. When an error is incorporated in the viral genome, it leads to mutation and recombination occurs when two viruses infect the same host cell and exchange genetic information, which creates a novel virus. Recombinants can surface when the same person (or animal) is infected by more than one variant at the same time ('co-infection'). This allows the variants to interact during replication, mixing their genetic material and forming new combinations. Three SARS-CoV-2 recombinant variants with evidence of person-to-person transmission have been reported: XD (AY.4/BA.1 recombinant, where AY.4 is Delta), XE (BA.1/BA.2 recombinant) and XF (another AY.4/BA.1 recombinant) [14].

Risk of re-infection with BA.1 and BA.2

BA.2 differs from BA.1 in its genetic sequence, including some amino acid differences in the spike protein and other proteins. It has been shown that BA.2 has a growth advantage over BA.1 [12]. Studies are ongoing that are evaluating the risk of re-infection with BA.2 compared to BA.1. Re-infection with BA.2 following infection with BA.1 has been documented; however, initial data from population-level re-infection studies suggest that infection with BA.1 provides strong protection against re-infection with BA.2, at least for the limited period for which data are available. As Omicron has the ability to cause so many infections over a short period of time, many more people are being hospitalized than at any other time in the pandemic.

WHO tracks two new sub-variants (BA.4 & BA.5)

The WHO recently said that it was tracking two new Omicron sub-variants BA.4 and BA.5 to assess whether they are more infectious or dangerous [2]. The immune escape properties of these two new sub-variants are being studied by various clinical, epidemiological and immunological methods by leading researchers in South Africa, which was the first country to report Omicron. Oliveira and his team are conducting one of the world's strongest genomic surveillance programmes for SARS-CoV2. It is reported that there were several abnormal SARS-CoV2 genome sequences with notable mutations that encode its spike protein. By the first week of April, it was found that BA.4 and BA.5 sequences comprised around 50% of the roughly 500 genomes sequences in South Africa. Immune escape potential of these sub-variants is being studied by immunologists by exposing samples of BA.4 and BA.5 to blood drawn from people infected with COVID-19 and people who have been vaccinated.

Booster vaccine dose

Boosters for COVID-19 vaccines may be required because the first dose can only unreliably activate the body's immune system, and the second provides consistent protection against COVID-19. Immunity is better three months after the Moderna vaccine and six months after Oxford shots, but this immunity lasts only for few months after the vaccination. Furthermore, since coronavirus is rapidly mutating into new variants like the Omicron, our immune cells may not identify the mutated virus, and thus, we may need a booster vaccine shot to tackle new strains [8, 11]. The children and younger students are not vaccinated yet in India as only very recently COVID-19 vaccination has been announced to be started for 15–18 years age group from January 3, 2022, so as to avoid Omicron infection to this younger category [10].

Omicron as a natural vaccine

Some researchers have asserted that Omicron can provide natural vaccination while others have refuted this claim. Omicron may act as a vaccine because it allows a large number of people to effectively develop herd immunity against the Omicron, halting transmission in the same way that vaccination develops herd immunity [5]. This variant has the potential to enhance immunity in individuals without causing major sickness. Omicron is similar to live attenuated vaccines in certain ways as it causes milder infection and triggers a strong immune response against viruses. Immunity developing in vaccinated persons (infected with Omicron) can be paired with immunity against the previous variant to generate a threshold level of herd immunity, allowing 70–90% of people to be recovered from or vaccinated against COVID-19. Also, according to some scientists, considering Omicron as a natural vaccine is a perilous idea [5]. It creates complacency and is based more on pandemic fatigue and incapacity to do more than on current data and that Omicron is not a vaccine; no matter how light it may be, because this variant has resulted in deaths and hospital admissions worldwide.

Nasal Omicron vaccine booster

Current vaccination modalities provides less protection against contracting and transmitting the Omicron variants compared with earlier variants, it still provides some protection, especially after the third or fourth booster dose. A recent research published in a reputed journal described an ultra-effective nasal vaccine booster that potently induced the extraordinary high-level of neutralizing antibody in pre-vaccinated mice [9]. This particular vaccine booster is composed of a recombinant receptor binding domain of SARS-CoV-2 spike (either wild-type or omicron) fused with a domain of SARS-CoV-2 nucleoprotein. In the absence of adjuvants, a single intranasal administration of the

booster significantly induced systemic and mucosal antibody responses in pre-vaccinated mice and also minimizes the chances of irritation or allergy to the mucosa. Most importantly, the single dose nasal vaccine booster (omicron version) potently enhanced the neutralizing activity against authentic SARS-CoV-2 omicron virus infection. However, these nasal protein boosters warrant further studies and clinical trials in humans before being successfully applied to human populations.

Aircraft wastewater sampling for new variants

A recent study detected the presence of Omicron variant in aircraft wastewater sample from a flight arriving in Northern Territory of Australia by using RT-qPCR assays per guidance from the WHO [1]. The sequencing of nasopharyngeal swab of one of the patients infected with SARS-CoV-2 resulted in the detection of Omicron VOC. It is difficult to identify all COVID-19 positive cases among arriving passengers by doing only pre-flight testing of clinical samples, therefore under these circumstances, post-flight testing of passengers may be beneficial when potentially more-infectious variants are predicted to be emerging globally, and quarantine measures may be necessary when new variants cause increase disease severity. Further studies are needed to identify other suitable sample matrices such as air sampling or surface swab sampling to determine whether these are more appropriate than wastewater.

Ukraine war and COVID-19

There is a well-established link between war and disease outbreaks extending back centuries. It challenges every public health program existing in the country. It limits the availability of medical care for those who might be seriously ill, and often fosters COVID-19 transmission when so many people are crowded into bomb shelter locations, trains and refugee processing facilities. Ukraine was struggling to control the pandemic even before the Russian invasion. Vaccination campaigns in Ukraine were much slower as compared to other neighbouring European countries [15]. Till the end of February 2022, only 35% of its population had been vaccinated. Since the war began, COVID testing has decreased as health care facilities have been destroyed and Russian attacks have cut off humanitarian aid routes. The millions of refugees who are crossing Ukrainian border and entering surrounding European countries will need treatment for their medical problems including COVID 19. These countries should be well prepared to handle the demands on their health systems as many European countries are already witnessing spurge in cases caused by Omicron sub-variant BA.2.

CONCLUSION

As the whole world was advancing towards normalcy after three waves of the pandemic, COVID-19 cases are again beginning to rise owing to Omicron and its new sub-variants. The newly detected sub-variants of Omicron are more transmissible and have the potential for immune escape. Booster shots of the vaccine can provide some amount of protection from the new sub-variants. Research is being conducted on new nasal vaccine formulations that can effectively neutralize the new variants, however human trials of these vaccine candidates are still in nascent stage. Populations experiencing pandemic fatigue could possibly ignore reports of new outbreaks, relaxing preventative behaviours and leading to additional transmissions. We should realize the fact that pandemic is not yet over. We should not lower our guard and there is an urgent need to increase public communications to adhere to mask-wearing especially by vulnerable populations. At the individual level, people need to do self-assessment of risk and follow Covid-appropriate behaviour accordingly.

Conflict of interest

The Authors declare no conflict of interest.

REFERENCES

1. Ahmed W., Bivins A., Smith W.J.M., Metcalfe S., Stephens M., Jennison A.V., Moore F.A.J., Bourke J., Schlebusch S., McMahon J., Hewitson G., Nguyen S., Barcelon J., Jackson G., Mueller J.F., Ehret J., Hosegood I., Tian W., Wang H., Yang L., Bertsch P.M., Tynan J., Thomas K.V., Bibby K., Graber T.E., Ziels R., Simpson S.L.: Detection of the Omicron (B.1.1.529) variant of SARS-CoV-2 in aircraft wastewater. *Sci Total Environ.* 2022;820:153171. doi: 10.1016/j.scitotenv.2022.153171.
2. Are new Omicron subvariants a threat? Here's how scientists are keeping watch. Available at: www.nature.com. Accessed on 19th April, 2022.
3. China COVID outbreak: Shanghai residents struggle for medicine, food. Available at: www.economictimes.indiatimes.com. Accessed on 18th April, 2022.
4. Covid cases surpass 500mn as Omicron sub-variant surges. Available at: www.epapertribuneindia.com. Accessed on 15th April, 2022.
5. Das S., Samanta S., Banerjee J., Pal A., Giri B., Kar S.S., Dash S.K.: Is Omicron the end of pandemic or start of a new innings? *Travel Med Infect Dis.* 2022;48:102332. doi: 10.1016/j.tmaid.2022.102332.
6. Dhawan M., Priyanka., Choudhary O.P.: Emergence of Omicron sub-variant BA.2: Is it a matter of concern amid the COVID-19 pandemic? *Int J Surg.* 2022;99:106581. doi: 10.1016/j.ijssu.2022.106581.
7. Dimeglio C., Loubes J.M., Miguères M., Sauné K., Trémeaux .P, Lhomme S., Ranger N., Latour .J, Mansuy JM., Izopet J.: Influence of vaccination and prior

- immunity on the dynamics of Omicron BA.1 and BA.2 sub-variants. *J Infect.* 2022;S0163-4453(22)00140-2. doi: 10.1016/j.jinf.2022.03.014.
8. *Koyama T., Miyakawa K., Tokumasu R., S Jeremiah S., Kudo M., Ryo A.*: Evasion of vaccine-induced humoral immunity by emerging sub-variants of SARS-CoV-2. *Future Microbiol.* 2022;17:417-4. doi: 10.2217/fmb-2022-0025.
 9. *Lam J.Y., Ng Y.Y., Yuen C.K., Wong W.M., Yuen K.Y., Kok K.H.*: A nasal omicron vaccine booster elicits potent neutralizing antibody response against emerging SARS-CoV-2 variants. *Emerg Microbes Infect.* 2022;11:964-7. doi: 10.1080/22221751.2022.2053365.
 10. *Mohapatra R.K., Tiwari R., Sarangi A.K., Sharma S.K., Khandia R., Saikumar G., Dhama K.*: Twin combination of Omicron and Delta variants triggering a tsunami wave of ever high surges in COVID-19 cases: A challenging global threat with a special focus on the Indian subcontinent. *J Med Virol.* 2022 ;94:1761-5. doi: 10.1002/jmv.27585.
 11. *Sapkota B., Saud B., Shrestha R., Al-Fahad D., Sah R., Shrestha S., Rodriguez-Morales A.J.*: Heterologous prime-boost strategies for COVID-19 vaccines. *J Travel Med.* 2021. doi: 10.1093/jtm/taab191.
 12. Statement on Omicron sublineage BA.2. Available at: www.who.int. Accessed on 20th April, 2022.
 13. Update on Omicron. Available at: <https://www.who.int/news/item/28-11-2021-update-on-omicron>. Accessed on: 18th April, 2022.
 14. Variants update. Available at: health.gov.nz. Accessed on 21st April 2022.
 15. Why Ukraine's COVID-19 Problem Is Everyone's Problem. Available at: www.time.com/6153254/ukraine-russia-war-covid-19. Accessed on: 21st April 2022.
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ATTITUDES TOWARDS VEGETABLES AND FRUITS RICH IN BIOACTIVE COMPOUNDS IN A GROUP OF INDIVIDUALS AGED 20-39 YEARS OLD

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ABSTRACT

Background. Due to the high percentage of deaths caused by non-communicable chronic diseases, such as cancer or cardiovascular diseases, recorded in recent years, proper nutrition, including consumption of vegetables and fruit rich in bioactive compounds is of a vital importance. It is especially important in the light of consumers' interest in pro-health values of foods.

Objective. Aim of this study, was to assess the attitudes of people aged 20-39 towards food with a specific health effect, with particular emphasis on selected vegetables and fruits rich in bioactive compounds.

Material and methods. The study included 500 people aged 20-39 years old. The research tool was a questionnaire consisting of 3 parts, which assessed: attitudes of people aged 20-39 towards the health values of food, frequency of consumption of selected vegetables and fruits rich in bioactive compounds and knowledge about them.

Results. The average result of respondents' given answers indicated their positive attitude towards health values of food (mean = 4.41). Nevertheless, consumption frequency of selected vegetables and fruits was low or very low among more than half (57%) of the respondents. In addition, members of the study group demonstrated insufficient knowledge about the confirmed by clinical tests, positive impact of the consumption of examined products on health (average knowledge test result = 25% among the members of the test group). At the same time, higher consumption of analysed vegetables and fruits was associated with better knowledge about them. Similarly, more positive attitudes towards health values of food were associated with higher frequency of vegetables and fruit consumption and knowledge about them.

Conclusions. The surveyed adults aged 20-39 showed a positive attitude towards health values of food. Nevertheless, consumption of selected vegetables and fruits rich in bioactive compounds and knowledge about them was not sufficient. Due to the association between better knowledge about health values of particular products and frequency of their consumption, in the future, focus should be placed on increasing consumers' knowledge in this area, e.g. by organizing social and information campaigns.

Key words: *vegetables, fruit, polyphenols, glucosinolates, carotenoids, non-communicable chronic diseases*

STRESZCZENIE

Wprowadzenie. Ze względu na notowany w ostatnich latach, wysoki odsetek zgonów spowodowanych niezakaźnymi chorobami przewlekłymi, takimi jak nowotwory czy choroby sercowo-naczyniowe, niezwykle istotne jest prawidłowe żywienie, w tym spożycie warzyw i owoców wyjątkowo bogatych w składniki bioaktywne. Jest to ważne, w obliczu zainteresowania konsumentów walorami prozdrowotnymi spożywanej żywności.

Cel. Celem badania była ocena postaw osób w wieku 20-39 lat wobec żywności o określonym działaniu zdrowotnym, ze szczególnym uwzględnieniem wybranych warzyw i owoców bogatych w składniki bioaktywne.

Material i metodyka. Badanie przeprowadzono wśród 500 osób w wieku 20-39 lat. Narzędziem badawczym był kwestionariusz ankiety składający się z 3 części, w których oceniono: postawy osób w wieku 20-39 lat wobec walorów prozdrowotnych żywności, częstotliwość spożycia wybranych warzyw i owoców bogatych w składniki bioaktywne oraz wiedzę na ich temat.

Wyniki. Uzyskane wyniki wskazywały na pozytywną postawę respondentów wobec walorów zdrowotnych żywności (średnia = 4,41). Mimo to, częstotliwość spożycia wybranych warzyw i owoców była niska lub bardzo niska wśród ponad połowy (57%) respondentów. Osoby badane wykazywały również niedostateczną wiedzę na temat potwierdzonych badaniami klinicznymi aspektów pozytywnego wpływu spożycia badanych warzyw i owoców na zdrowie (średni wynik testu wiedzy wyniósł w grupie badanej 25%). Jednocześnie, wyższa częstotliwość spożycia analizowanych warzyw i owoców było powiązane z wyższym poziomem wiedzy respondentów na ich temat. Podobnie, bardziej prozdrowotne postawy respondentów wobec walorów zdrowotnych żywności, były powiązane z wyższą częstotliwością spożycia badanych warzyw i owoców oraz wiedzą na ich temat.

Wnioski. Badane osoby w wieku 20-39 lat wykazywały pozytywne nastawienie do walorów zdrowotnych żywności. Mimo to, spożycie wybranych warzyw i owoców bogatych w składniki bioaktywne oraz wiedza na ich temat nie były dostateczne. Ze względu na powiązanie między większą wiedzą na temat działania poszczególnych produktów, a ich spożyciem, w przyszłości należałoby skupić się na działaniach mających na celu zwiększanie posiadanej przez konsumentów wiedzy w tym zakresie, np. poprzez organizacje kampanii społecznych i informacyjnych.

Słowa kluczowe: *warzywa, owoce, polifenole, glukozynolany, karotenoidy, przewlekłe choroby niezakaźne*

INTRODUCTION

According to data published by the World Health Organization [39], in 2019, around 7 out of 10 deaths were caused by so-called chronic non-communicable diseases (such as: ischemic heart disease, stroke, type 2 diabetes, lung diseases or cancers). One of the main risk factors for diseases of this category is improper diet, including insufficient consumption of vegetables and fruit.

Both vegetables and fruit are rich sources of bioactive compounds, such as polyphenols, carotenoids, glucosinolates, indoles and allyl sulfur compounds [4]. Significant amounts of anthocyanins, belonging to the group of polyphenols, can be found in red and purple fruits and vegetables, while red fruits, such as pomegranate, strawberries and cranberries are also rich sources of ellagotannins [21, 34]. Resveratrol, a chemical compound belonging to the group of stilbenes, can mainly be found in red grapes, while cruciferous vegetables are rich sources of glucosinolates and indoles [11, 32]. Onions and garlic contain significant amounts of allyl sulfur compounds and carotenoids can be found in red, orange, yellow and green vegetables such as carrots, bell peppers, broccoli and spinach as well as in red, orange and yellow fruits such as apricot, peach, mango or nectarine [22, 35]. Generally speaking, while their amount may vary between the species, bioactive compounds can be found in almost every kind of known vegetable and fruit.

Numerous studies concerning pro-health effects of fruit and vegetable consumption are being conducted, mostly focusing on products containing the highest amounts of potentially health-promoting compounds. It has been observed, that particular benefits for heart-health might be associated with the consumption of such fruits and vegetables as: tomatoes, cabbage, kale, broccoli, garlic, blueberries, strawberries, black currant, pomegranates, red grapes and cranberries. On the other hand, regular consumption of garlic, broccoli, cabbage, tomatoes, blueberries, red grapes, pomegranates, strawberries and cranberries might have a positive effect on both prevention and treatment of type 2 diabetes. At the same time, beneficial effect on cancer prevention can be associated with regular consumption of vegetables and fruits such as tomatoes, blueberries, pomegranates, strawberries and cranberries. Lastly,

prevention of neurodegenerative disorders such as Alzheimer's disease might be supported by the consumption of blueberries, strawberries and red grapes. All fruits and vegetables mentioned above are rich sources of dietary bioactive compounds and, as such, may positively affect prevention of non-communicable chronic diseases by the means of their antioxidative properties (e.g. resulting in anti-inflammatory effect or reduction of oxidized LDL-cholesterol levels) and immunomodulatory properties (e.g. by preventing the formation of neoplastic lesions by reducing cell proliferation rate, impacting cell cycle arrest, increasing glutathione peroxidase synthesis or inducing phase II enzymes responsible for carcinogen metabolism) [24, 37]. Another important mechanism of bioactive compounds' effect on health and non-communicable chronic diseases risk reduction is related to their gene-regulatory properties (e.g. sulforaphane can decrease cancer risk by activating cancer suppressor genes) [37].

Due to the proven, positive effect of vegetable and fruit consumption, particularly associated with vegetables and fruits rich in bioactive compounds, on health, it is reasonable to increase their amount in daily diet, which should not be difficult, considering a relatively easy access to products belonging to these assortment groups. At the same time, promotion of vegetable and fruit consumption should be encouraged by the pro-health trends in consumers' eating habits observed in recent years [7,10]. However, positive attitudes towards health values of food, often do not correspond with their higher consumption. As demonstrated by Kozirok et al. [18], high price and changes in organoleptic properties, may be considered a significant obstacle, discouraging consumers from buying foods with particular health value. The above-mentioned problem could be solved by encouraging consumers to buy vegetables and fruits that are naturally rich in bioactive ingredients (and therefore do not require chemical composition changes), and are relatively cheap (especially when they are bought during their season). Therefore, consumption of fruit and vegetables rich in bioactive compounds, could meet both the current needs of food consumers and nutritional recommendations for the population, while contributing to the improvement of general health.

Aim of this study, was to assess the attitudes of people aged 20-39 towards food with a specific health

effect, with particular emphasis on selected vegetables and fruits rich in bioactive compounds. Our goal was to assess consumption frequency of selected vegetables and fruits and possible associations between their consumption, knowledge about their pro-health effects and general attitudes towards health values of food. Conclusions about the existence of such associations can be used as a basis for further promotion of health and healthy diet.

MATERIAL AND METHODS

The study was conducted between October 2020 and February 2021. Purposive sampling of typical units (due to age) was used. Age below 20 or above 39 years old was considered an exclusion criterion. Respondents were informed about the purpose of this study and its anonymity at the beginning of the survey.

The diagnostic survey method and the survey technique were used. The survey was posted on the Internet. The research tool was an anonymous questionnaire. In the first part of the questionnaire, a fragment of the HTAS questionnaire (Health and Taste Attitude Scales) [31] concerning general health interest was used. In this part of the questionnaire, a seven-point Likert scale [20] was used to assess attitudes towards health values of food (where 1 = strongly disagree and 7 = strongly agree). The analysed attitude included the following statements: "health value of food has little influence on the way I choose food products", "health values of foods I eat are of a great importance to me", "I eat what I like and do not think about the impact of food on my health", "my diet is always healthy and balanced", "it is important that my diet contains a lot of vitamins and minerals", "I do not pay attention to health values of the food I eat between main meals" and "it is important to me that my diet is low in fat.". An interpretation system was used to assess attitudes, in which an average score < 3.80 indicated an anti-health or negative attitude, an average score ≥ 3.80 , but ≤ 4.20 a neutral attitude, and an average score > 4.20 - a pro-health or positive attitude. To interpret some questions, the reverse scoring system was used (i.e. the answer "I strongly disagree" was awarded 7 points, and the answer "I strongly agree" - 1 point). Then, the share of individual components (positive, neutral, negative) in the whole analysed attitude was calculated. The result has been shown as a percentage.

The next part of the survey consisted of author's questionnaire regarding the frequency of consumption of selected vegetables and fruits rich in bioactive compounds. The following vegetables, fruits and their products were included in the study: broccoli, broccoli sprouts, kale, cabbage (raw, cooked and fermented), garlic, chili pepper, raw tomatoes, dried tomatoes,

tomato-based products (such as tomato paste and ketchup), tomato juice, blueberries*, black currants*, black currant juice, red grapes, pomegranate, pomegranate juice, strawberries*, cranberries and cranberry juice). For the purpose of more accurate and detailed result interpretation, analysed vegetables and fruits were divided into following groups: cruciferous vegetables (broccoli, broccoli sprouts, cabbage, kale), raw vegetables (broccoli, broccoli sprouts, raw cabbage, garlic, chili pepper, kale, raw tomato), processed vegetables (cooked cabbage, fermented cabbage, tomato juice, dried tomato, tomato paste and ketchup), raw fruits (blueberries, black currants, red grapes, pomegranate, strawberries, cranberries) and processed fruits (black currant juice, pomegranate juice, cranberry juice). The analysed group of products was deliberately selected, using the high amount of bioactive compounds described in the literature as a criterion. Additionally, chosen products met nutrition claim inclusion criteria set by the European Commission, due to their significant content of vitamins and/or minerals. In the case of vegetables and fruits available seasonally, members of the study group were asked to indicate their usual consumption during the season for a given product. In this part of the questionnaire, a scale was used, in which the answer "never or almost never" was given no points, the answer "less than once a month" was given 1 point, the answer "several times a month" - 2 points, the answer "several times a week" - 3 points, the answer "once a day" - 4 points, and the answer "several times a day" - 5 points. Then, the points received by the respondents were summed up and compared to their maximum possible number in a given category. The following values were chosen as cut-off points for interpretation of the results: $<15\%$ of possible points - very low consumption, $15-30\%$ - low consumption, $31-50\%$ - medium consumption, $51-70\%$ - high consumption, $>70\%$ - very high consumption. Obtaining more than 70% of points in the part concerning the frequency of consumption of products was considered very high, due to the fact that the author's study included only 12 selected vegetables and fruits, while the respondents could also eat other products from these assortment groups. Moreover, obtaining 70% of points meant, averaging, that a given person consumed half of the tested products every day, and the other half - several times a week, i.e.: very often. Average consumption frequencies were calculated by adding together all the points given to each response on the frequency of consumption of a given product, and then, dividing them by the number of respondents (500).

The last part of the questionnaire contained statements about health-promoting effects of selected vegetables and fruits rich in bioactive compounds. In this part of the questionnaire, a total of 36 points

could be scored (15 in the part concerning vegetables, 21 in the part concerning fruit). Individual points were awarded for selecting the correct answers (1 correct answer = 1 point). Content of statements concerning health-promoting effects of vegetables and fruit consumption was developed on the basis of the subject literature (the results of clinical trials and/or cohort studies). These statements were used to assess respondents' knowledge about health values of particular vegetables and fruits.

In total, the survey consisted of 31 single-choice and multiple-choice questions. At the end of the survey, respondents were asked to fill in their particulars.

Microsoft Office Excel version 2101 was used to develop the database. The IBM SPSS Statistics version 26 package was used to perform statistical analyses. Spearman's rho correlation test, post hoc tests with Dunn-Bonferroni correction and Friedman tests were used. The threshold $\alpha = 0.05$ was adopted as the level of statistical significance.

RESULTS

Study group consisted of 500 adults aged 20-39 (411 females and 89 males), and the assumed age range was an inclusion criterion for the study. Among the respondents, 51% declared having secondary education, and 48.4% - higher education. Only 0.6% declared their education as primary or basic vocational.

Among members of the study group, analysed attitude towards health values of food was positive in around 60% of cases, and neutral in around 40% of them. Negative attitude wasn't observed for any of the statements, therefore its share in analysed attitude equalled 0%. After calculating the mean result from all the examined statements, respondents' attitude towards health values of food was determined to be positive (pro-health) and amounted to 4.41.

Consumption of analysed vegetables and fruits was low or very low among 57.2% of the respondents. Consumption of cruciferous vegetables was

particularly low - among 80.2% of respondents it was at a low or a very low level. A higher percentage of people consuming high or very high amounts of analysed products was recorded in the case of raw and processed vegetables (7.4%) than in the case of raw and processed fruits (4.6%). The percentage indicating high or very high consumption did not exceed 10% of the respondents in any of the analysed subgroups. Interpretation of the results concerning frequency of consumption of each group of analysed vegetables and fruits has been presented in Table 1.

After analysing the average frequency of consumption of vegetables selected for this study, it was shown that tomato was the most frequently consumed raw vegetable among the respondents (average consumption frequency = 3.38), while garlic took the second place (average consumption frequency = 2.59). The most often consumed among processed vegetables, were tomato products, such as tomato paste or ketchup (average consumption frequency = 2.93). Strawberries were the most often consumed among fruits included in this study (average consumption frequency = 2.43), followed by blueberries (average consumption frequency = 1.98). It was also observed, that the consumption of some fruits and vegetables traditionally grown in Poland (i.e.: kale, cabbage, broccoli, black currant, cranberry) was at a relatively low level. Average consumption frequencies of above-mentioned products were: fermented cabbage = 1.61, broccoli = 1.61, cranberries = 1.27, cooked cabbage = 1.22, raw cabbage = 1.21, black currant = 1.20, kale = 0.74.

In the part concerning respondents' knowledge about health-promoting effects of individual vegetables and fruits included in the study, it was noted that the average result of the respondents was 9 points (out of 36 possible), which gave the percentage result of 25%, i.e.: definitely insufficient. Among members of the study group, especially low knowledge concerning awareness of the impact of selected vegetables and fruits in prevention and treatment of type 2 diabetes

Table 1. Frequency of consumption of each group of analysed vegetables and fruits (presented as a percentage of respondents)

Analysed group of products	Very low consumption	Low consumption	Medium consumption	High consumption	Very high consumption
Selected vegetables and fruits (raw and processed)	6.0	51.2	37.8	4.0	1.0
Selected vegetables (raw and processed)	2.8	45.4	44.4	6.4	1.0
Selected cruciferous vegetables (raw and processed)	25.2	55.0	15.2	3.2	1.4
Selected fruits (raw and processed)	24.6	41.8	27.2	4.8	1.6
Selected vegetables and fruits (raw)	6.2	40.8	44.4	7.4	1.2

n = 500

was noted. The mean score in this case was only 1 point (14%). The most frequent result obtained by the respondents in this part of the test was 0 points. The respondents were slightly more aware of the impact of vegetable and fruit consumption on prevention and support of treatment of cardiovascular diseases and cancers. The mean scores in these categories were 2 points (18%) and 1 point (20%), respectively. Nevertheless, it should be noted that, when it comes to cancer awareness, the most frequently obtained result was 0 points (Table 2).

Statistical analysis carried out as a part of the study, showed that more positive attitudes towards health values of food were associated with better knowledge about vegetables and fruits (Table 3).

Similarly, more positive attitudes towards health values of food were associated with higher frequency of fruit and vegetable consumption (Table 4). Moreover, better knowledge about fruits and vegetables was associated with more frequent consumption of analysed vegetables and fruits, vegetables alone, raw products and cruciferous vegetables (Table 5).

Table 2. Respondents' knowledge about health-promoting effects of selected vegetables and fruits (presented as number of points)

The scope of the knowledge tested	Max number of points	X ± SD	Min ÷ Max	Dominant
Knowledge about health-promoting effects of selected vegetables and fruits	36	9 ± 4.0	2 ÷ 27	7
Knowledge about health-promoting effects of selected vegetables	15	3 ± 1.6	0 ÷ 8	4
Knowledge about health-promoting effects of selected fruits	21	5 ± 2.9	0 ÷ 18	3
Knowledge about the effects of fruit and vegetable consumption on the prevention and/or treatment of type 2 diabetes	9	1 ± 1.5	0 ÷ 7	0
Knowledge about the effects of fruit and vegetable consumption on the prevention and/or treatment of cardiovascular diseases	11	2 ± 2.2	0 ÷ 11	2
Knowledge about the effects of fruit and vegetable consumption on the prevention and/or treatment of cardiovascular diseases	5	1 ± 1.4	0 ÷ 5	0

X – mean value. SD – standard deviation. Min – minimum value, Max – maximum value, n = 500

Table 3. Knowledge about vegetables and fruits in relation to attitudes towards health values of food

Knowledge about vegetables and fruits		Attitude towards health benefits of food
Vegetables and fruits	RHO	0.26
	p	<0.001
Vegetables	RHO	0.21
	p	<0.001
Fruits	RHO	0.22
	p	<0.001
Effects of fruit and vegetable consumption on the prevention and/or treatment of type 2 diabetes	RHO	0.09
	p	0.044
Effects of fruit and vegetable consumption on the prevention and/or treatment of cardiovascular diseases	RHO	0.18
	p	<0.001
Effects of fruit and vegetable consumption on the prevention and/or treatment of cardiovascular diseases	RHO	0.22
	p	<0.001

This table shows the correlations between knowledge about vegetables and fruits and attitudes towards health values of food. RHO – Spearman's rank correlation coefficient, p – statistical significance, n = 500

Table 4. Attitudes towards health values of food in relation to frequency of consumption of analysed vegetables and fruits

Consumption frequency of:		Attitude towards health benefits of food
all analysed products	RHO	0.22
	p	<0.001
all analysed products	RHO	0.28
	p	<0.001
fruits	RHO	0.09
	p	0.046
raw products	RHO	0.24
	p	<0.001
processed products	RHO	0.12
	p	0.005
cruciferous vegetables	RHO	0.25
	p	<0.001

This table shows the correlations between attitudes towards health values of food and frequency of consumption of analysed vegetables and fruits, RHO – *Spearman's* rank correlation coefficient, p – statistical significance, n = 500

Table 5. Knowledge about vegetables and fruits in relation to their consumption frequency

Knowledge concerning:		Consumption frequency of:					
		all analysed products	vegetables	fruits	raw products	processed products	cruciferous vegetables
vegetables and fruits	RHO	0,10	0,10	0,07	0,13	-0,01	0,10
	p	0,021	0,026	0,094	0,004	0,848	0,030

This table shows the correlation between knowledge about analysed vegetables and fruits and frequency of their consumption. RHO – *Spearman's* rank correlation coefficient, p – statistical significance, n = 500

DISCUSSION

Results of the conducted study indicate, that while respondents' attitude towards health values of food was positive, frequency of vegetable and fruit consumption and knowledge about them was definitely insufficient.

In the conducted study, three aspects of respondents' attitudes (emotional, behavioural and cognitive) were analysed in accordance with the ABC (affect, behaviour, cognition) attitude model [26]. The emotional aspect of respondents' attitudes concerned their beliefs about the health values of food. From this part of our study, a conclusion could be drawn that the respondents were rather pro-health oriented. Similar findings were reported by *Babicz-Zielińska* et al. and *Kozirok* et al. [2, 16, 17], whose studies reported that respondents had expressed a desire for their diet to be rich in vitamins and minerals and low in fat (in the study by *Kozirok* et al. [16], the willingness to eat a low-fat diet was recorded only in women). At the same time, in a study by *Kucharska* et al. [19] conducted in the group of dietetics students, it was noted that the consumption of vitamins A, E, C, B1, B2, B3, B6, folate, as well as phosphorus, sodium, zinc and magnesium was at a level exceeding their recommended daily

allowance (RDA). Nevertheless, the above-mentioned study showed that potassium, calcium and iron were deficient in the respondents' diet. This may serve as an indication that, despite the willingness of adults to consume vitamins and minerals, there are still some deficiencies in this respect, which, in turn, may indicate a lack of knowledge about dietary sources of these nutrients or an aversion to them.

In our study, the behavioural aspect of respondents' attitudes towards vegetables and fruits rich in bioactive compounds was examined by determining the frequency of consumption of individual raw and processed products. Similarly to our study, in the study conducted by the *Kantar* data company [27], tomato was declared to be the most eagerly consumed vegetable in Poland. In this study, the remaining vegetables particularly rich in bioactive compounds, took the 6th (cabbage) and 10th (broccoli) place and were eaten several times less frequently than the most popular tomatoes, which is consistent with the results of our own research. Among the respondents of our own study, strawberries were the most frequently consumed berries, followed by blueberries, cranberries and blackcurrants. In a study conducted by the *Kantar* data company [27], strawberries were second most

consumed fruits in the group of adult Poles (83% of respondents declared that they eat it strawberries at least once a week during season). Blueberries were ranked 7th in this study, and blackcurrants - 8th (38% and 24% of respondents consuming them at least once a week during the season, respectively). Cranberry was not present in the top ten of the Kantar study [27] - such results were therefore relatively similar to the results of our own study, at least in the context of declared frequency of consumption of selected berries. Similarly, in a study by *Malczyk* et al. [23], berries consumed most frequently by the respondents were strawberries, followed by cranberries and currants. Blueberries were not included in this study. At the same time, it is worth mentioning that in comparison to fruits from other groups, cranberry was only on the 20th place, and currant - on the 23rd in terms of frequency of consumption recorded in the study by *Malczyk* et al. [23].

Red grapes were ranked third in the results of our research regarding average frequency of unprocessed fruit consumption, while pomegranate was ranked 6th (last). In a study by *Malczyk* et al. [23], red grapes were ranked 8th in terms of consumption frequency, with average consumption determined to be „rare”. On the other hand, in a study by *Olewnicki* et al. [28] it was noted that 36% of respondents had never bought a pomegranate fruit. At the same time, in a study by the Kantar data company [27] and a study by *Malczyk* et al. [23], pomegranate consumption wasn't even included, which may indicate its low popularity among Polish customers.

Analysis of frequency of consumption of vegetables, fruit and their products among the respondents of our study has shown, that in 57% of cases it was at a low or a very low level. This kind of data is consistent with the one presented as a result of the Kantar data company research [27], in which only 5% of the respondents declared consuming vegetables and fruit more than once a day. In our study, an extremely low consumption was recorded in the case of cruciferous vegetables - as many as 80% of surveyed adults declared low or very low consumption of vegetables belonging to that group. According to *Bosetti* et al. [6], the average consumption of this group of vegetables in the Swiss population was 11 g / day, and their share in the total consumption of vegetables was only 7%. The same was true for the Swedish population, where the average consumption of cruciferous vegetables was 11 g / day, and their share in the total vegetable consumption was 15%. However, it is essential for a similar study to be conducted in the Polish population.

As a result of statistical analysis, our study showed that more pro-health attitudes towards health and nutrition were associated with higher consumption frequencies of vegetables and fruits rich in bioactive

compounds. Similarly, a study by *Bihan* et al. [5], showed that positive attitudes towards statements such as “my diet is healthy” or “I eat vegetables and fruit to maintain good health” positively correlated with the amount of fruit and vegetables consumed.

The last, cognitive aspect of the respondents' attitudes was examined by assessing their knowledge about the health-promoting properties of selected vegetables and fruits. Awareness of the impact of individual raw vegetable and fruit consumption on prevention and treatment of type 2 diabetes was especially low (average result = 11%). Among vegetables and fruits included in our survey, for as many as 9 of them, results of clinical trials showing a positive impact of their consumption on prevention or support of treatment of this disease could be found. For example, as demonstrated in a study by *Bahadoran* et al. [3], broccoli consumption had a positive effect on parameters such as cholesterol levels and level of oxidative stress among patients with type 2 diabetes, thus reducing the risk of complications. Similarly, *Kim* et al. [15] showed that consumption of fermented cabbage reduced fasting glucose levels, similar results were also obtained by *Wang* et al. [38] in the case of garlic consumption. *Muraki* et al. [25], observed, in turn, that consuming 3 servings of blueberries a week lowered the risk of type 2 diabetes by as much as 26%, while *Esmailzadeh* et al. [12] – that consumption of pomegranate juice had a positive effect on the laboratory parameters of patients with this disease. The effect on prevention and/or treatment of type 2 diabetes was also shown in the case of such products as: tomatoes, red grapes and strawberries.

A positive influence of as many as 11 out of 12 vegetables and fruits analysed in our study (all except chili pepper) on heart-health could be found in scientific literature, and the average result of the respondents' knowledge in this regard was 2 points (18%). It is a proof of respondents' insufficient knowledge, as a positive influence of consumption of selected vegetables and fruits on cardiovascular health is relatively well proven in scientific research. For example, in a study by *Kim* et al. [16], it was shown that consumption of kale had potential to increase concentrations of HDL cholesterol and decrease concentrations of LDL cholesterol. A similar effect, in terms of the elevating effect on HDL cholesterol levels, was reported by *Cuevas-Ramos* et al. [9] in a study concerning tomato consumption. Meanwhile, according to *Asgary* et al. [1], consumption of pomegranate juice had a statistically significant effect on lowering blood pressure. A similar effect was reported by *Kim* et al. [15], in a study on fermented cabbage (kimchi). Both the reduction of blood pressure and the improvement of lipid parameters are

recognized factors reducing the risk of cardiovascular diseases [30].

In our study, a slightly higher level of knowledge, than the one regarding the impact of consumption of selected vegetables and fruits on prevention or treatment of type 2 diabetes and cardiovascular diseases was reported in the part concerning cancers. The average result obtained by the respondents in this respect was 20% (1 out of 5 possible points). This result was still extremely underwhelming, especially for the group of respondents with predominantly pro-health attitudes. A positive, anti-cancer effect of five products analysed in our study could be found in scientific research, such knowledge should therefore also be available to the respondents. An example of a study in which such an effect was confirmed was the study by *Giovanucci et al.* [14], in which the authors showed that consumption of tomatoes correlated negatively with the occurrence of prostate cancer. Similarly, as described by *Student et al.* [33], the consumption of cranberries could also be effective and, as noted by *Pantuck et al.* [29] – so could be the consumption of pomegranates. At the same time, consumption of blueberries could, according to *Thomasset et al.* [36] have a positive effect on the remission of gastrointestinal cancer, as could the consumption of strawberries, as proven by *Chung et al.* [8].

As a result of the statistical analysis carried out in our study, it was shown that higher frequency of consumption of vegetables and fruit was associated with better knowledge about them. Such results were consistent with those obtained by *Farragher et al.* [13], who found that those with greater food and nutrition knowledge were more likely to eat vegetables. This means that education on the pro-health effects of selected vegetables and fruits may have a significant impact on their consumption.

CONCLUSIONS

1. Members of the study group have shown positive attitudes towards health values of food.
2. The overall consumption of analysed vegetables and fruits was relatively low. Particularly low consumption was noted for products such as kale, cabbage, broccoli, blackcurrant and cranberry, which are customarily grown in Poland and are widely available.
3. The respondents' knowledge about health-promoting properties of analysed vegetables and fruits was definitely insufficient. It was shown that better knowledge about health-promoting effects of selected vegetables and fruits was associated with higher frequency of their consumption.
4. While respondents' positive attitudes towards health values of food may prove useful in a process

of building their pro-health behaviours in the future, courses of action to accomplish higher consumption of vegetables and fruits rich in bioactive compounds should be considered. The first step could consist of increasing awareness of their health-effects (for example by using social campaigns and promotional campaigns), it could also be helpful to increase the knowledge about ways to use vegetables and fruit in a daily diet (e.g. as an addition to salads, soups, cocktails, desserts, milk-based dishes, sandwich spreads, groats, pasta. Special focus should be placed on promoting vegetables and fruits grown in Poland. Such action could take place in cooperation with Polish agricultural unions (e.g. producers of cruciferous vegetables).

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. *Asgary S., Sahebkar A., Afshani M. R., Keshvari M., Haghjooyjavanmard S., Rafieian-Kopaei M.*: Clinical evaluation of blood pressure lowering, endothelial function improving, hypolipidemic and anti-inflammatory effects of pomegranate juice in hypertensive subjects. *Phytother Res* 2014; 28(2), 193-199.
2. *Babicz-Zielińska E., Komorowska-Szczepańska W., Bardo Z.*: Postawy i poglądy dziewcząt w stosunku do diety o działaniu prozdrowotnym [Girls' attitudes and views towards a health-promoting diet]. *Probl Hig Epidemiol* 2011; 92, 451-454 (in Polish).
3. *Bahadoran Z., Mirmiran P., Hosseinpour F., Hedayati M., Hosseinpour-Niazi S., Azizi F.*: Broccoli sprouts reduce oxidative stress in type 2 diabetes: a randomized double-blind clinical trial. *Eur J Clin Nutr* 2011; 65(8), 972-977.
4. *Biesalski H.-K., Dragsted L. O., Elmadfa I., Grossklaus R., Müller M., Schrenk D., Walter P., Weber P.*: Bioactive compounds: Definition and assessment of activity. *Nutr.* 2009; 25(11-12), 1202-1205.
5. *Bihan H., Castetbon K., Mejean C., Peneau S., Pelabon L., Jellouli F., Le Clesiau H., Hercberg S.*: Sociodemographic factors and attitudes toward food affordability and health are associated with fruit and vegetable consumption in a low-income French population. *J Nutr* 2010; 140(4), 823-830.
6. *Bosetti C., Negri E., Kolonel L., Ron E., Franceschi S., Preston-Martin S., Mabuchi K.*: A pooled analysis of case-control studies of thyroid cancer. VII. Cruciferous and other vegetables (International). *Cancer Causes Control* 2002; 13(8), 765-775.
7. *Butterworth M., Davis G., Bishop K., Reyna L., Rhodes A.*: What Is a Superfood Anyway? Six Key Ingredients for Making a Food "Super". *Gastronomica* 2020; 20(1), 46-58.

8. Chung M. J., Lee S. H., Sung N. J.: Inhibitory effect of whole strawberries, garlic juice or kale juice on endogenous formation of N-nitrosodimethylamine in humans. *Cancer Lett* 2002; 182(1), 1-10.
9. Cuevas-Ramos D., Almeda-Valdés P., Chávez-Manzanera E., Meza-Arana C. E., Brito-Córdova G., Mehta R., Perez-Mendez O., Gómez-Pérez F. J.: Effect of tomato consumption on high-density lipoprotein cholesterol level: a randomized, single-blinded, controlled clinical trial. *Diabetes Metab Syndr Obes* 2013; 6, 263.
10. Dejnaka A.: Sposoby odżywiania się przez konsumentów – nowe trendy [Ways of eating by consumers - new trends]. E-Wydawnictwo. Prawnicza i Ekonomiczna Biblioteka Cyfrowa. Wydział Prawa, Administracji i Ekonomii Uniwersytetu Wrocławskiego, 2019 (in Polish).
11. Dinkova-Kostova A. T., Kostov R. V.: Glucosinolates and isothiocyanates in health and disease. *Trends Mol Med* 2012; 18(6), 337-347.
12. Esmailzadeh A., Tahbaz F., Gaieni I., Alavi-Majd H., Azadbakht L.: Concentrated pomegranate juice improves lipid profiles in diabetic patients with hyperlipidemia. *J Med Food* 2004; 7(3), 305-308.
13. Farragher T., Wang W. C., Worsley A.: The associations of vegetable consumption with food mavenism, personal values, food knowledge and demographic factors. *Appetite* 2016; 97, 29-36.
14. Giovannucci E., Rimm E. B., Liu Y., Stampfer M. J., Willett W. C.: A prospective study of tomato products, lycopene, and prostate cancer risk. *J Natl Cancer Inst* 2002; 94(5), 391-398.
15. Kim E. K., An S.-Y., Lee M.-S., Kim T. H., Lee H.-K., Hwang W. S., Choe S.J., Kim T.Y., Han S.J., Kim H. J., Kim D.J., Lee K.W.: Fermented kimchi reduces body weight and improves metabolic parameters in overweight and obese patients. *Nutr Res* 2011; 31(6), 436-443.
16. Kim S. Y., Sun Y., Kwon S. M., Park K. S., Lee-Kim Y. C.: Kale juice improves coronary artery disease risk factors in hypercholesterolemic men. *Biomed Environ Sci* 2008; 21(2), 91-97.
17. Kozirok W., Baumgart A., Babicz-Zielińska E.: Postawy i zachowania konsumentów wobec żywności prozdrowotnej [Consumers' attitudes and behavior towards healthy food]. *Bromatol Chem Toksyk*. 2012; 45(3), 1030-1034 (in Polish).
18. Kozirok W., Marciszewicz E., Babicz-Zielińska E.: Postawy i zachowania kobiet wobec żywności prozdrowotnej [Attitudes and behavior of women towards healthy food]. *Studia i Prace WNEiZ US* 2016; 43, 199-208 (in Polish).
19. Kucharska A., Oleksiak N., Sińska B., Zegan M., Michota-Katulaska E.: Warzywa i owoce źródłem witamin i składników mineralnych w diecie studentek dietetyki [Vegetables and fruits as sources of vitamins and minerals in the diets of female dietetics students]. *Bromat. Chem. Toksykol* 2016; 49(2), 145-151 (in Polish).
20. Likert R.: A technique for the measurement of attitudes. *Arch Psychol* 1932.
21. Lorenzo J. M., Munekata P. E., Putnik P., Kovačević D. B., Muchenje V., Barba F. J.: Sources, chemistry, and biological potential of ellagitannins and ellagic acid derivatives. *Stud Nat Prod Chem* 2019; 60, 189-221.
22. Maiani G., Periago Castón M.J., Catasta G., Toti E., Cambrodón I.G., Bysted A., Granado-Lorencio F., Olmedilla-Alonso B., Knuthsen P., Valoti M., Böhm V., Mayer-Miebach E., Behnlian D., Schlemmer U.: Carotenoids: actual knowledge on food sources, intakes, stability and bioavailability and their protective role in humans. *Mol. Nutr. Food Res.* 2009;53(S2), S194-S218
23. Malczyk E., Całyniuk Z., Syc M.: Ocena częstości spożycia warzyw i owoców przez studentów uniwersytetu medycznego w Lublinie [Assessment of the frequency of fruit and vegetable consumption by students of the medical university in Lublin]. *Bromat Chem Toksyk* 2016 , 49, 4, 780–787 (in Polish)
24. Mokhtari R. B., Baluch N., Homayouni T. S., Morgatskaya E., Kumar S., Kazemi P., Yeager H.: The role of Sulforaphane in cancer chemoprevention and health benefits: a mini-review. *J Cell Commun Signal* 2018; 12(1), 91-101.
25. Muraki I., Imamura F., Manson J. E., Hu F. B., Willett W. C., Van Dam R. M., Sun Q.: Fruit consumption and risk of type 2 diabetes: results from three prospective longitudinal cohort studies. *Br Med J* 2013; 347
26. Myers D., *Psychologia społeczna [Social Psychology]*, Poznań, Zysk i S-ka, 2003.
27. Narodowe badania konsumpcji warzyw i owoców [National research on fruit and vegetable consumption], Kantar Public 2020. Available: <https://www.pap.pl/centrum-prasowe/615833%2Ckantarnajpopularniejsze-warzywa-i-owoce-w-polsce.html> (Accessed 1.12.2020)
28. Olewnicki D., Sobczak W., Gunerka L.: Zainteresowanie warszawskich konsumentów owocami mało znanymi i egzotycznymi [The interest of Warsaw residents in little-known and exotic fruits]. *Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego. Ekonomia i Organizacja Gospodarki Żywnościowej* 2016; (114) (in Polish).
29. Pantuck A., Pettaway C. A., Dreicer R., Corman J., Katz A., Ho A., Aronson W., Clark W., Simmons G., Heber D.: A randomized, double-blind, placebo-controlled study of the effects of pomegranate extract on rising PSA levels in men following primary therapy for prostate cancer. *Prostate Cancer Prostatic Dis* 2015; 18(3), 242-248.
30. Pencina M. J., Navar A. M., Wojdyla D., Sanchez R. J., Khan I., Ellassal J., D'Agostino R.B. Peterson E.D., Sniderman A. D.: Quantifying Importance of Major Risk Factors for Coronary Heart Disease. *Circulation* 2019; 139(13), 1603-1611. doi:10.1161/CIRCULATIONAHA.117.031855.
31. Roininen K., Tuorila H., Zandstra E., De Graaf C., Vehkalahti K., Stubenitsky K., Mela D. J.: Differences in health and taste attitudes and reported behaviour among Finnish, Dutch and British consumers: a cross-

- national validation of the Health and Taste Attitude Scales (HTAS). *Appetite* 2001; 37(1), 33-45.
32. Shen T., Wang X.-N., Lou H.-X.: Natural stilbenes: an overview. *Nat Prod Rep* 2009; 26(7), 916-935.
33. Student V., Vidlar A., Bouchal J., Vrbkova J., Kolar Z., Kral M., Kosina P., Vostalova J.: Cranberry intervention in patients with prostate cancer prior to radical prostatectomy. Clinical, pathological and laboratory findings. *Biomedical Papers of the Medical Faculty of Palacky University in Olomouc* 2016; 160(4).
34. Szaniawska M., Taraba A., Szymczyk K.: Budowa, właściwości i zastosowanie antocyjanów [Structure, properties and application of anthocyanins]. *Nauki Inż Technol* 2015; (2 (17)) (in Polish).
35. Tadeusiewicz J., Krysztofiak A., Olas B.: Czosnek - panacea na choroby układu krążenia? [Garlic - a panacea for cardiovascular diseases?]. *Kosmos* 2014; 63(1), 37-44 (in Polish).
36. Thomasset S., Berry D. P., Cai H., West K., Marczylo T. H., Marsden D., Brown K., Dennison A., Garcea G., Miller A., Hemingway D., Steward W.P., Gescher A.J.: Pilot study of oral anthocyanins for colorectal cancer chemoprevention. *Cancer Prev Res* 2009; 2(7), 625-633.
37. Tomczyk J., Olejnik A.: Sulforafan – potencjalny czynnik w prewencji i terapii chorób nowotworowych [Sulforaphane – a possible agent in prevention and therapy of cancer]. *Postepy Hig Med Dosw (Online)* 2010; 64, 590-603 (in Polish).
38. Wang J., Zhang X., Lan H., Wang W.: Effect of garlic supplement in the management of type 2 diabetes mellitus (T2DM): a meta-analysis of randomized controlled trials. *J Food Nutr Res* 2017; 61(1).
39. World Health Organization, The top 10 causes of death, 2020. Available: <https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death> (accessed 25.10.2021).

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CONSUMPTION OF SELECTED GROUPS OF FOOD PRODUCTS BY MEDICAL AND NON-MEDICAL STUDENTS DURING THE COVID-19 PANDEMIC

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ABSTRACT

Background. A properly balanced diet should provide multiple valuable nutrients necessary for the proper functioning of the body through the proper frequency of consuming food products that are their source. This is particularly important during the pandemic when there is a need to support the immune system.

Objective. The aim of the study was to assess the frequency of consumption of selected groups of food products and to determine whether this frequency differs among medical and non-medical students in the period before and during the COVID-19 pandemic.

Material and methods. The study was conducted among 435 Polish and Turkish students using an original questionnaire. The proper study was preceded by a pilot study in 40 participants. The Wilcoxon test was used to assess the differences in the frequency of consumption of selected groups of products among medical and non-medical students both during and before the pandemic. A value of $p < 0.05$ was considered statistically significant.

Results. Significant differences were observed in the frequency of consumption of: sweets ($p = 0.02$ among medical students), salty snacks ($p = 0.03$ among both groups of students), fast food products ($p = 0.00$ among medical and $p = 0.01$ among non-medical students) and energy drinks ($p = 0.02$ among medical and $p = 0.00$ among non-medical student) in the analysed periods of time before and during the COVID-19 pandemic.

Conclusions. The study showed that during the pandemic, the frequency of food products consumption in the study groups of students from medical and non-medical faculties is mostly satisfactory. There were significant differences in the frequency of consumption of sweets, salty snacks, fast food products and energy drinks in both groups of students.

Key words: *frequency of consumption, nutrition, pandemic, students, eating behaviours*

STRESZCZENIE

Wstęp. Odpowiednio zbilansowana dieta powinna dostarczać organizmowi wielu cennych i niezbędnych do prawidłowego funkcjonowania organizmu składników odżywczych, poprzez właściwą częstość spożycia produktów spożywczych będących ich źródłem. Jest to szczególnie ważne w trakcie pandemii ze względu na możliwość wspierania odporności.

Cel. Celem pracy była ocena częstości spożycia wybranych grup produktów spożywczych i stwierdzenie czy istnieją różnice w częstości spożycia wśród studentów kierunków medycznych i niemedycznych, w okresie przed i podczas trwania pandemii COVID-19.

Material i metody. Badanie zostało przeprowadzone wśród 435 studentów narodowości polskiej i tureckiej za pomocą autorskiego kwestionariusza ankiety. Badanie właściwe zostało poprzedzone badaniem pilotażowym, którym objęto 40 osób. Do oceny różnic w częstości spożycia wybranych grup produktów wśród studentów kierunków medycznych i niemedycznych zarówno w trakcie pandemii, jak i przed nią zastosowano test Wilcoxon. Za istotne statystycznie uznano wyniki gdzie poziom istotności $p < 0.05$.

Wyniki. W analizowanych okresach czasu przed i w trakcie pandemii COVID-19 istotne różnice zaobserwowano w częstości spożycia: słodczy ($p = 0,02$ wśród studentów kierunków medycznych), słonych przekąsek ($p = 0.03$ wśród obu grup

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studentów), produktów typu fast food ($p=0,00$ wśród studentów kierunków medycznych i $p=0,01$ wśród niemedycznych) oraz napojów energetycznych ($p=0,02$ wśród studentów medycznych i $p=0,00$ wśród studentów niemedycznych).

Wnioski. Badania wykazały, że w czasie pandemii częstość spożycia produktów spożywczych w badanych grupach studentów zarówno kierunków medycznych, jak i niemedycznych jest w większości zadowalająca. W obu grupach studentów występowały istotne różnice w częstości spożycia słodczy, słonych przekąsek, produktów typu fast food oraz napojów energetycznych.

Słowa kluczowe: częstość spożycia, odżywianie, pandemia, studenci, zachowania żywieniowe

INTRODUCTION

The ongoing Sars-CoV-2 pandemic gives rise to many negative states and emotions, such as constant anxiety, fear, stress, fatigue and depression [26]. Despite the passage of time, remote work, online schooling and other pandemic-related limitations have brought about adverse changes in many dimensions, especially in social relations, mental and physical health, as well as have contributed to disturbing lifestyle changes, including eating [5, 15, 22]. Meanwhile, nutrition is very important as a properly balanced diet provides our bodies with multiple valuable nutrients necessary for the proper development. This is of key importance as proper nutrition enhances the immune system, which plays a critical role in combating the virus [3]. It should be therefore ensured that the diet used is rich in unprocessed products, macro- and microelements, such as high-quality proteins, polyunsaturated fatty acids and vitamins, A, C, E and group B vitamins in particular, as well as minerals, such as selenium and zinc [4]. Regular supply of these nutrients can contribute to a significant improvement of immunity, which is of great importance during Sars-CoV-2 pandemic [9]. At this point, it is worth paying attention to whether our everyday eating behaviours are consistent with the current recommendations. Proper selection of nutritional products to boost the immune system and thus reduce the risk of coronavirus infection is recommended [28].

During the pandemic, both medical and non-medical university students are a population characterised by multiple changes on many levels, as confirmed by abundant scientific evidence [5, 15, 22, 26]. These changes are caused, among others, by social isolation or limited social contacts leading to many irregularities, including eating disorders, which may in turn contribute to e.g. abnormal body weight [2]. It is generally recommended to have 4 to 5 meals a day. The meals should contain appropriate nutrients and should be consumed at regular times (at certain intervals), starting with breakfast no later than one hour after waking up, and ending with supper no later than 2 to 3 hours before bedtime. It is essential that these meals contain an adequate amount of high-quality food products. An appropriate frequency of consumption of these foods is also important.

Generally, food products can be classified into two major categories - healthy and unhealthy. Healthy products, which should be consumed at the highest possible frequency, include milk and dairy products, eggs, fatty sea fish, lean meats, vegetables and fruits, nuts, vegetable fats, grain products, and dry legume seeds. These are essential dietary components due to both their content of valuable substances, such as flavonoids, antioxidants, vitamins, dietary fiber, and their anti-inflammatory properties, which reduce the risk of chronic metabolic diseases, including diabetes, cardiovascular diseases and some types of cancer [4, 12, 19]. On the other hand, the group of unhealthy products, the consumption of which should be limited to the necessary minimum in order to gradually and completely eliminate them from the daily diet, include, among others, fast-foods and instant foods, highly processed products, sweetened beverages, sweets, salty snacks, high-fat meats, animal fats, as well as all types of stimulants (including alcohol, drugs and tobacco products), which contribute to the development of many chronic metabolic diseases that may be responsible for premature death [11, 20, 21].

The aim of the study was to assess the frequency of consumption of selected groups of food products and to determine whether this frequency differs among medical and non-medical students in the period before and during the COVID-19 pandemic.

MATERIALS AND METHODS

The study was conducted among 435 Polish and Turkish students, aged 17-27, during the COVID-19 pandemic, in the winter season (period from November 2020 to February 2021), during the intensification of restrictions related to the spread of the virus. The selection of the study group was related to the authors' willingness to present the impact of the pandemic on the lifestyle of the multicultural group. The questionnaire, which included products and meals consumed both in Poland and in Turkey, was distributed with the use of social media, among internet groups of medical and non-medical students, in the appropriate language. All questionnaires were completed correctly. The participants were informed about the anonymity of the study and the use of data solely for scientific purposes. An original questionnaire enquiring about background

data, such as the mode, form and field of study, was used. The questionnaire also asked about the number of meals per day and breakfast consumption, as well as the frequency of consumption of selected groups of food products in the period before and during the COVID-19 pandemic.

The proper study was preceded by a pilot study in 40 participants. Ultimately, 196 questionnaires completed by medical students and 239 questionnaires completed by non-medical students were collected. Data processing was performed using Microsoft Excel 2010 and Statistica 13.1 software. The *Wilcoxon* test was used to assess the differences in the frequency of consumption of selected groups of products among medical and non-medical students both during and before the pandemic. A value of $p < 0.05$ was considered statistically significant.

RESULTS

The number of meals eaten a day and breakfast consumption before and during the pandemic are shown in Table 1.

The majority of medical students consumed 4-5 meals a day both before and during the pandemic (51% and 44.4%, respectively), whereas non-medical students had 3 meals a day (44.8% and 40.6%, respectively). The majority of both medical and non-medical students declared that they always had breakfast before and during the pandemic (56.6% and 70.9% medical students, and 49.4% and 64.4% non-medical students, respectively).

The frequency of consumption of selected plant products before and during the pandemic are presented in Table 2.

Most medical students reported that they had several servings of vegetables and fruit per day before and during the pandemic (44.9% and 47.4% for vegetables, and 38.3% and 40.3% for fruit, respectively). The largest group of non-medical students consumed vegetables once a day before the pandemic, and several

times a week during the pandemic (34.3% and 32.2%, respectively), while they usually had several servings of fruit per week both before and during the pandemic (34.3% and 35.1%, respectively).

Both groups of students consumed whole grain cereal products several times a day before and during the pandemic (50.5% and 49.5% of medical students, and 40.6% and 40.6% of non-medical students, respectively).

The highest percentage of medical students had several servings of nuts and seeds per week (31.1% and 35.2%, respectively) both before and during the pandemic, while the largest percentage of non-medical students consumed these products several times a month (33.1% and 38.1%, respectively).

The highest percentage of medical students consumed legume seeds several times a week before and during the pandemic (46.4% and 51.5%, respectively) compared to several times a month in the case of non-medical students (35.1% and 33.1% respectively).

No statistically significant differences were found in the frequency of consumption of plant products between medical and non-medical students in the analysed periods of time before and during the pandemic.

The frequency of consumption of the selected products of animal origin before and during the pandemic are presented in Table 3.

Both before and during the pandemic, the highest percentage of students from both groups consumed milk and dairy products several times a week (39.8% and 36.7% of medical students, and 38.1% and 36.8% of non-medical students, respectively).

The largest group of medical and non-medical students consumed cottage and rennet cheeses several times a week both before and during the pandemic. Cottage cheese was consumed by 46.9% and 41.8% of medical students, 41.8% and 38.9% of non-medical students, respectively; rennet cheeses were consumed by 37.2% and 39.3% of medical students, and 42.3% and 41% of non-medical students, respectively).

Table 1. Amount of meals and breakfast consumption by studied medical and non-medical students

Tested factor		Before pandemic				During pandemic			
		Medical		Non-medical		Medical		Non-medical	
		N 196	%	N 239	%	N 196	%	N 239	%
Amount of meals	<3	15	7.7	21	8.8	35	17.9	40	16.7
	3	74	37.8	107	44.8	67	34.2	97	40.6
	4-5	100	51	106	44.4	87	44.4	95	39.7
	>5	7	3.6	5	2.1	7	3.6	7	2.9
Breakfast consumption	Always	111	56.6	118	49.4	139	70.9	154	64.4
	Occasionally	69	35.2	75	31.4	47	24	68	28.5
	Never	16	8.2	46	19.2	10	5.1	17	7.1

Table 2. Frequency of consumption of selected plant products before and during the pandemic

Frequency of consumption		Before the pandemic				During the pandemic				Differences in consumption	
		Medical		Non-medical		Medical		Non-medical		Medical	Non-medical
		N 196	%	N 239	%	N 196	%	N 239	%	p- value	
Vegetables	Several times a day	88	44.9	67	28	93	47.4	68	28.5	0.07	0.07
	Once a day	31	15.8	82	34.3	30	15.3	68	28.5		
	Several times a week	62	31.6	70	29.3	64	32.7	77	32.2		
	Several times a month	5	2.6	12	5	5	2.6	17	7.1		
	Occasionally	8	4.1	8	3.3	1	0.5	8	3.3		
	Never	2	1	0	0	3	1.5	1	0.4		
Fruit	Several times a day	75	38.3	55	23	79	40.3	50	20.9	0.10	0.69
	Once a day	42	21.4	60	25.1	44	22.4	63	26.4		
	Several times a week	54	27.6	82	34.3	55	28.1	84	35.1		
	Several times a month	14	7.1	27	11.3	12	6.1	29	12.1		
	Occasionally	10	5.1	15	6.3	5	2.6	13	5.4		
	Never	1	0.5	0	0	1	0.5	0	0		
Whole grain cereal products	Several times a day	99	50.5	97	40.6	97	49.5	97	40.6	0.51	0.93
	Once a day	35	17.9	65	27.2	31	15.8	59	24.7		
	Several times a week	43	21.9	57	23.8	45	23	65	27.2		
	Several times a month	11	5.6	11	4.6	17	8.7	12	5		
	Occasionally	7	3.6	6	2.5	6	3.1	4	1.7		
	Never	1	0.5	3	1.3	0	0	2	0.8		
Nuts and seeds	Several times a day	11	5.6	11	4.6	7	3.6	8	3.3	0.82	0.17
	Once a day	23	11.7	24	10	24	12.2	18	7.5		
	Several times a week	61	31.1	62	25.9	69	35.2	61	25.5		
	Several times a month	58	29.6	79	33.1	53	27	91	38.1		
	Occasionally	33	16.8	48	20.1	34	17.3	39	16.3		
	Never	10	5.1	15	6.3	9	4.6	22	9.2		
Legumes	Several times a day	8	4.1	3	1.3	4	2	9	3.8	0.48	0.57
	Once a day	10	5.1	11	4.6	10	5.1	10	4.2		
	Several times a week	91	46.4	72	30.1	101	51.5	61	25.5		
	Several times a month	51	26	84	35.1	50	25.5	79	33.1		
	Occasionally	27	13.8	52	21.8	25	12.8	59	24.7		
	Never	9	4.6	17	7.1	6	3.1	21	8.8		

The largest group of medical and non-medical students consumed fish several times a month both before and during the pandemic (39.3% and 40.3% of medical students, 44.8% and 43.9% of non-medical students, respectively).

No statistically significant differences were found in the frequency of consumption of animal products between medical and non-medical students in the analysed periods of time before and during the pandemic. The frequency of consumption of the selected products harmful to health before and during the pandemic are presented in Table 4

The largest group of medical and non-medical students consumed sweets and salty snacks several times a week both before and during the pandemic. Sweets were consumed by 37.8% and 43.4% of medical students, and 42.3% and 40.6% of non-medical students, respectively. The group of medical students consuming sweets once a day during the pandemic decreased by 5.1% compared to the time before the pandemic. Salty snacks were consumed several times a week by 33.2% and 31.1% of medical students and 40.2% and 37.2% of non-medical students, respectively. The group of medical students consuming salty snacks once a day

Table 3. Frequency of consumption of the selected products of animal origin before and during the pandemic

Frequency of consumption		Before the pandemic				During the pandemic				Differences in consumption	
		Medical		Non-medical		Medical		Non-medical		Medical	Non-medical
		N 196	%	N 239	%	N 196	%	N 239	%	p-value	
Milk and milk drinks	Several times a day	62	31.6	34	14.2	66	33.7	35	14.6	0.87	0.43
	Once a day	37	18.9	59	24.7	33	16.8	54	22.6		
	Several times a week	78	39.8	91	38.1	72	36.7	88	36.8		
	Several times a month	11	5.6	29	12.1	16	8.2	37	15.5		
	Occasionally	4	2	16	6.7	4	2	14	5.9		
	Never	4	2	10	4.2	5	2.6	11	4.6		
Cottage cheese	Several times a day	41	20.9	21	8.8	47	24	19	7.9	0.63	0.28
	Once a day	18	9.2	23	9.6	17	8.7	26	10.9		
	Several times a week	92	46.9	100	41.8	82	41.8	93	38.9		
	Several times a month	28	14.3	60	25.1	30	15.3	63	26.4		
	Occasionally	8	4.1	24	10	10	5.1	24	10		
	Never	9	4.6	11	4.6	10	5.1	14	5.9		
Rennet cheeses	Several times a day	17	8.7	19	7.9	16	8.2	20	8.4	0.66	0.47
	Once a day	16	8.2	43	18	21	10.7	38	15.9		
	Several times a week	73	37.2	101	42.3	77	39.3	98	41		
	Several times a month	46	23.5	37	15.5	41	20.9	44	18.4		
	Occasionally	28	14.3	22	9.2	16	8.2	21	8.8		
	Never	16	8.2	17	7.1	25	12.8	18	7.5		
Fish	Several times a day	1	0.5	0	0	0	0	1	0.4	0.31	0.28
	Once a day	2	1	3	1.3	1	0.5	4	1.7		
	Several times week	45	23	37	15.5	52	26.5	43	18		
	Several times a month	77	39.3	107	44.8	79	40.3	105	43.9		
	Occasionally	42	21.4	66	27.6	35	17.9	56	23.4		
	Never	29	14.8	26	10.9	29	14.8	30	12.6		

during the pandemic decreased by 4% compared to the time before the pandemic.

The largest percentage of medical students consumed fast foods occasionally before and during the pandemic (36.7% and 41.8%, respectively), while non-medical students consumed fast foods several times a month (34.3% and 35.1%, respectively). The group of medical students who do not consume eat fast food during the pandemic increased by 10.2%, while the group of non-medical students increased by 6.2%.

Most respondents in both groups declared that they did not consume energy drinks (62.8% and 68.4% of medical students, and 51% and 59.8% of non-medical students, respectively). The group of medical students who do not consume energy drinks increased by 5.6% during the pandemic, while the group of non-medical students increased by 8.8%.

In the analysed time periods, statistically significant differences were found in the frequency

of consumption of salty snacks, fast food products and energy drinks among medical and non-medical students, as well as in the frequency of consumption of sweets among medical students before and during the pandemic.

DISCUSSION

In the present study, the highest percentage of medical students consumed the recommended number of 4 to 5 meals a day both before and during the pandemic (51% and 44.4%, respectively), whereas the highest percentage of non-medical students consumed 3 meals a day (44.8% before and 40.6% during the pandemic).

The number of consumed meals decreased in both cases. *Fila-Witecka* et al., who assessed lifestyle changes caused by the COVID-19 pandemic among 980 Polish students, showed that 43.92% of these

Table 4. Frequency of consumption of products harmful to health before and during the pandemic

Frequency of consumption		Before the pandemic				During the pandemic				Differences in consumption	
		Medical		Non-medical		Medical		Non-medical		Medical	Non-medical
		N 196	%	N 239	%	N 196	%	N 239	%	p-value	
Sweets	Several times a day	22	11.2	35	14.6	17	8.7	37	15.5	0.02	0.12
	Once a day	34	17.3	46	19.2	24	12.2	37	15.5		
	Several times a week	74	37.8	101	42.3	85	43.4	97	40.6		
	Several times a month	38	19.4	28	11.7	36	18.4	32	13.4		
	Occasionally	24	12.2	23	9.6	25	12.8	27	11.3		
	Never	4	2	6	2.5	9	4.6	9	3.8		
Salty snacks	Several times a day	12	6.1	16	6.7	4	2	13	5.4	0.03	0.03
	Once a day	9	4.6	14	5.9	12	6.1	14	5.9		
	Several times a week	65	33.2	96	40.2	61	31.1	89	37.2		
	Several times a month	56	28.6	69	28.9	60	30.6	65	27.2		
	Occasionally	46	23.5	34	14.2	49	25	41	17.2		
	Never	8	4.1	10	4.2	10	5.1	17	7.1		
Fast food products	Several times a day	3	1.5	2	0.8	0	0	3	1.3	0.00	0.01
	Once a day	2	1	6	2.5	3	1.5	10	4.2		
	Several times a week	42	21.4	64	26.8	33	16.8	43	18		
	Several times a month	67	34.2	82	34.3	48	24.5	84	35.1		
	Occasionally	72	36.7	76	31.8	82	41.8	75	31.4		
	Never	10	5.1	9	3.8	30	15.3	24	10		
Energy drinks	Several times a day	1	0.5	3	1.3	0	0	5	2.1	0.02	0.00
	Once a day	4	2	16	6.7	4	2	11	4.6		
	Several times a week	17	8.7	26	10.9	11	5.6	15	6.3		
	Several times a month	18	9.2	25	10.5	21	10.7	20	8.4		
	Occasionally	33	16.8	47	19.7	26	13.3	45	18.8		
	Never	123	62.8	122	51	134	68.4	143	59.8		

respondents declared a reduction in the amount of food they consumed (13). In turn, *Sidor and Rzymiski* [25] assessed eating habits in 1,097 Polish adults during the COVID-19 pandemic and found an increase in the amount of food consumed among 43.5% of respondents and an increased number of snacks among 51.8% of respondents.

There were no significant changes in breakfast consumption in the analysed periods of time ($p > 0.05$) among medical and non-medical students participating in the present study. Different findings were obtained by *Ismail et al.*, who investigated eating habits and lifestyle behaviours among 2,507 Lebanese adults. The authors observed a significant increase in the frequency of breakfast consumption during the COVID-19 pandemic [17]. In turn, *Husain and Ashkanani* [16], who assessed changes in the dietary habits of 415 adult Kuwaitians during the COVID-19 pandemic, found no significant changes

in the regularity of breakfast consumption, which is in line with the present study. Regular consumption of breakfast during the analysed periods was declared by 61.2% of respondents before the pandemic and 58.2% during the pandemic. In the study on lifestyle and dietary habits before and during the COVID-19 pandemic and quarantine in Brazil, *Souza et al.* [27] reported that the frequency of breakfast consumption decreased during the pandemic compared to the pre-pandemic period. Differences in the results obtained between the cited publications may be due to the type of the group and its place of residence.

In the present study, the percentage of non-medical students consuming vegetables decreased during the pandemic. Most respondents in this group consumed vegetables once a day (34.3%) before the pandemic, and several times a week (32.2%) during the pandemic. There were no changes in the frequency of vegetable consumption

among medical students. These results may suggest greater knowledge of medical university students about the ingredients contained in vegetables that have a beneficial effect on the immune system.

Sidebottom et al. [24], who assessed the impact of COVID-19 pandemic and quarantine and physical activity and eating habits of 291 U.S. students, found no statistically significant differences in the amount of vegetables consumed in the analysed periods before and during the pandemic ($p > 0.05$), as in the group of medical students. *Branaccio* et al., [8] who assessed the impact of the COVID-19 pandemic on professional activity, dietary behaviours, eating habits, and physical activity in the university population of Naples, found that the level of vegetable consumption was very similar both during and before the pandemic. The highest percentage of the surveyed students in the present study consumed cereal products several times a day both before and during the pandemic.

Bertrand et al. [6] assessed the impact of the COVID-19 pandemic on eating habits, physical activity and sedentary lifestyle among 125 Canadian university students; contrary to the findings obtained in the presented study, they found that the average frequency of daily cereal consumption decreased from 1.03 to 0.92 during the pandemic.

In the present study no differences in the frequency of nut consumption were found between medical and non-medical students in the analysed periods of time. Similar results were obtained by *Bertrand* et al. [7]. Different findings were reported by *HacıÖmerYılmaz* et al., [29] who assessed the impact of the pandemic on eating habits and consumer behaviours of 2,692 Turkish students of the Faculty of Health Sciences. The results indicate an increased consumption of nuts among 28.9% of these students.

The consumption of milk and dairy products among both groups participating in the present study did not change in the analysed time periods. The lack of changes in the consumption of dairy products by students of medical and non-medical universities could potentially result from the availability and price of dairy products. Milk and milk drinks are highly available and have a low price in both countries. Different findings were reported by *Celorio-Sarda* et al., [10] who investigated the impact of the COVID-19 pandemic on eating habits and lifestyle behaviours of 339 Spanish students and specialists in food science. The researchers observed an increased consumption of milk, cheese, yoghurt and kefir. The increase in the number of people consuming yoghurt and kefir was especially pronounced among students of gastronomic sciences, who accounted for 33.1% of the study group.

The consumption of fast-food products differed significantly in the study periods, both among medical ($p = 0.00$) and non-medical (p

$= 0.01$) students. Before the pandemic, 5.1% of medical students declared that they did not consume fast-food products, while this percentage increased to 15.3% during the pandemic. Despite the lack of information on the cause of the reduction of fast food products consumption, it is known that a large proportion of gastronomic services were closed during the pandemic. Therefore, it can be hypothesized that limited access to this type of products influenced the frequency of their consumption. In order to confirm the hypothesis, further research should be carried out, taking into account the reasons for the above differences. The difference in fast-food consumption was also observed by *Alfawaz* et al. [1], who investigated the impact of the COVID-19 pandemic on eating behaviours and physical activity among 1,965 Saudi Arabian adults. The study showed that the percentage of individuals who did not consume fast-foods increased from 1.5% to 3.7% during the pandemic.

Energy drinks were consumed occasionally by 16.8% students before and 13.3% during the pandemic, respectively, in both periods of time, and several times a month by non-medical students (10.5% before the pandemic and 8.4% during the pandemic, respectively). Significant differences in the frequency of consumption of this type of products were found in both groups. Similar results were obtained by *Błaszczuk-Bębenek* et al., [7] who compared eating behaviours among 312 Polish adults during the COVID-19 pandemic. The study showed that 78.5% of respondents did not consume energy drinks before the pandemic, and this percentage increased to 85.3% during the pandemic ($p < 0.05$). In turn, *Iurcov* et al. [18] showed in their cross-sectional study on the impact of the COVID-19 pandemic on academic activity and health among Romanian medical dentistry students that 86.14% of these respondents did not consume energy drinks, whereas regular consumption of these beverages was reported by 13.86% of respondents.

During the pandemic, the highest percentage of respondents consumed salty snacks several times a week. Such an answer was given by 31.1% of medical students and 37.2% of non-medical students. This may indicate eating salty snacks by students while staying at home, including quarantine time. *Sabilla* and *Mustakim* [23], who assessed food consumption among 413 public health students in Jakarta, showed that 54.5% of their respondents consumed salty snacks 1-3 times a week, which is a higher percentage compared to the present study.

There are differences in the findings reported by many scientists investigating COVID-19 pandemic-triggered changes in the lifestyle of young adults. Regardless of the above, promotion of a healthy

lifestyle and the principles of rational nutrition among medical and non-medical students should be preceded by collection of dietary data in a given group to provide targeted education that meets its specific needs.

CONCLUSIONS

Significant differences in the frequency of consumption of sweets, salty snacks, fast food products and energy drinks were observed both among medical and non-medical students in the analysed periods of time before and during the COVID-19 pandemic. The frequency of consumption of the analysed groups of food products by medical and non-medical students during the pandemic is mostly satisfactory.

It is recommended to implement nutrition education among both groups of students, with a particular emphasis on promoting food products that have a beneficial effect on health, i.e. vegetables, fruit, nuts, legume seeds, dairy products, and fish.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Alfawaz H., Amer O.E., Aljumah A.A., Aldisi D.A., Enani M.A., Aljohani N.J., Alotaibi N.H., Alshingetti N., Alomar S.Y., Khattak M.N.K., Sabico S., Al-Daghri N.M. Effects of home quarantine during COVID19 lockdown on physical activity and dietary habits of adults in Saudi Arabia. *Sci Rep.* 2021;11(1):5904. doi:10.1038/s41598-021-85330-2.
2. Alzahrani H.S., Saeedi A.A., Baamer K.M., Shalabi F.A., Alzahrani M.A. Eating Habits Among Medical Students at King Abdulaziz University, Jeddah, Saudi Arabia. *Int J Gen Med.* 2020;13:77–88.
3. Aman F., Masood S. How Nutrition can help to fight against COVID-19 Pandemic. *Pak J Med Sci.* 2020;36(COVID19-S4):121-S3.
4. Aune D., Giovannucci E., Boffetta P., Fadnes L.T., Kenum N., Norat T., Greenwood D.C., Riboli E., Vatten L.J., Tonstad S. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality—a systematic review and dose-response meta-analysis of prospective studies. *Int J Epidemiol.* 2017;46(3):1029-1056. doi:10.1093/ije/dyw319.
5. Bakaloudi DR., Jeyakumar DT., Jayawardena R., Chourdakis M. The impact of COVID-19 lockdown on snacking habits, fast-food and alcohol consumption: A systematic review of the evidence. *Clin Nutr* 2021. doi:10.1016/j.clnu.2021.04.020.
6. Bertrand L., Shaw K.A., Ko J., Deprez D., Chilibeck P.D., Zello G.A. The impact of the coronavirus disease 2019 (COVID-19) pandemic on university students' dietary intake, physical activity, and sedentary behavior. *Appl. Physiol. Nutr. Metab.* 2021;46:265–272. doi:10.1139/apnm-2020-0990.
7. Błaszczuk-Bębenek E., Jagielski P., Bolesławska I., Jagielska A., Nitsch-Osuch A., Kawalec P. Nutrition Behaviors in Polish Adults before and during COVID-19 Lockdown. *Nutrients.* 2020; 12(10):3084. <https://doi.org/10.3390/nu12103084>
8. Brancaccio M., Mennitti C., Gentile A., Coreale L., Buzzachera C.F., Ferraris C., Montomoli C., Frisso G., Borrelli P., Scudiero O. Effects of the COVID-19 Pandemic on Job Activity, Dietary Behaviours and Physical Activity Habits of University Population of Naples, Federico II-Italy. *Int. J. Environ. Res. Public Health* 2021;18:1502. doi:10.3390/ijerph18041502.
9. Butler M.J., Barrientosa R.M. The impact of nutrition on COVID-19 susceptibility and long-term consequences. *Brain Behav Immun.* 2020;87:53-54.
10. Celorio-Sardà R., Comas-Basté O., Latorre-Moratalla M.L., Zerón-Rugiero M.F., Urpi-Sarda M., Illán-Villanueva M., Farran-Codina A., Izquierdo-Pulido M., Vidal-Carou M.D.C. Effect of COVID-19 Lockdown on Dietary Habits and Lifestyle of Food Science Students and Professionals from Spain. *Nutrients* 2021;28;13(5):1494. doi:10.3390/nu13051494.
11. Ehlers A., Marakis G., Lampen A., Hirsch-Ernst K.I. Risk assessment of energy drinks with focus on cardiovascular parameters and energy drink consumption in Europe. *Food Chem Toxicol* 2019;130:109-121. doi:10.1016/j.fct.2019.05.028.
12. Evans C.E.L. Dietary fibre and cardiovascular health: a review of current evidence and policy. *Proc Nutr Soc.* 2020;79(1):61-67. doi:10.1017/S0029665119000673.
13. Fila-Witecka K., Senczyszyn A., Kołodziejczyk A., Ciulkowicz M., Maciaszek J., Misiak B., Szcześniak D., Rymaszewska J. Lifestyle Changes among Polish University Students during the COVID-19 Pandemic. *Int J Environ Res Public Health.* 2021;11;18(18):9571. doi:10.3390/ijerph18189571.
14. Gombart AF., Pierre A., Maggini S. A Review of Micronutrients and the Immune System-Working in Harmony to Reduce the Risk of Infection. *Nutrients* 2020;12(1):236.
15. Hassen TB., El Bilali H., Allahyari MS. Impact of COVID-19 on Food Behavior and Consumption in Qatar. *Sustainability* 2020;12:6973; doi:10.3390/su12176973.
16. Husain W., Ashkanani F. Does COVID-19 change dietary habits and lifestyle behaviours in Kuwait: a community-based cross-sectional study. *Environ Health Prev Med.* 2020;25:61. doi:10.1186/s12199-020-00901-5.
17. Ismail L.C., Hashim M., Mohamad M.N., Hassan H., Ajab A., Stojanovska L., Jarrar A.H., Hasan H., Jamous D.O.A., Saleh S.T., Daour R.A., Osaili T.M., Dhaheri A.S.A. Dietary Habits and Lifestyle During Coronavirus Pandemic Lockdown: Experience From Lebanon. *Front. Nutr.* 8:730425. 2021. doi:10.3389/fnut.2021.730425
18. Iurcov R., Pop L.M., Iorga M. Impact of COVID-19 Pandemic on Academic Activity and Health Status among Romanian Medical Dentistry Students; A Cross-

- Sectional Study. *Int. J. Environ. Res. Public Health* 2021;18:6041. doi:10.3390/ijerph18116041.
19. *Maleki S.J., Crespo J.F., Cabanillas B.* Anti-inflammatory effects of flavonoids. *Food Chem* 2019 Nov 30;299:125124. doi:10.1016/j.foodchem.2019.125124.
20. *Mohammadbeigi A., Asgarian A., Moshir E., Heidari H., Afrashteh S., Khazaei S., Ansari H.* Fast food consumption and overweight/obesity prevalence in students and its association with general and abdominal obesity. *J Prev Med Hyg* 2018;28;59(3):236-240. doi:10.15167/2421-4248/jpmh2018.59.3.830.
21. *Pérez-Gimeno G., Rupérez A.I., Vázquez-Cobela R., Herráiz-Gastesi G., Gil-Campos M., Aguilera C.M., Moreno L.A., Trabazo M.R.L., Bueno-Lozano G.* Energy Dense Salty Food Consumption Frequency Is Associated with Diastolic Hypertension in Spanish Children. *Nutrients* 2020;12(4):1027. doi:10.3390/nu12041027.
22. *Rodríguez-Besteiro Stephanie., Tornero-Aguilera JF., Fernandez-Lucas J., Clemente-Suarez VJ.* Gender Differences in the COVID-19 Pandemic Risk Perception, Psychology, and Behaviors of Spanish University Students. *Int. J. Environ. Res. Public Health* 2021;18:3908. doi:10.3390/ijerph18083908
23. *Sabilla M., Mustakim M.* Fast foods consumption among public health students in DKI Jakarta province during Covid-19 pandemic. *Al Insyirah International Scientific Conference On Health*. 2021;2:213-225.
24. *Sidebottom C., Ullevig S., Cheever K., Zhang T.* The effect of COVID-19 pandemic and quarantine period on physical activity and dietary habits of college-aged students. *Sports Med Health Sci.* 2021;2. doi:10.1016/j.smhs.2021.08.005.
25. *Sidor A., Rzymiski P.* Dietary Choices and Habits during COVID-19 Lockdown: Experience from Poland. *Nutrients* 2020;3;12(6):1657. doi:10.3390/nu12061657.
26. *Sokół-Szawłowska M.* Wpływ kwarantanny na zdrowie psychiczne podczas pandemii COVID-19 [Mental Health Impact of Quarantine During the COVID-19 Pandemic]. *Psychiatria* 2021;18(1):57-62 (in Polish).
27. *Souza T.C., Oliveira L.A., Daniel M.M., Ferreira L.G., Lucia C.M.D., Liboredo J.C., Anastacio L.R.* Lifestyle and eating habits before and during COVID-19 quarantine in Brazil. *PHN* 2021;1-11. doi:10.1017/S136898002100255X.
28. *Venter C., Eyerich S., Sarin T., Klatt K.C.* Nutrition and the Immune System: A Complicated Tango. *Nutrients* 2020;12(3):E818.
29. *Yilmaz H.O., Aslan R., Unal C.* Effect of the COVID-19 Pandemic on Eating Habits and Food Purchasing Behaviors of University Students. *National Public Health Journal* 2020;15(3):154-159. doi:10.21109/kesmas.v15i3.3897.

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SENSE OF SELF-EFFICACY AND THE CONTENT OF ENERGY AND NUTRIENTS IN THE DIET OF ELITE POLISH BASKETBALL PLAYERS

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ABSTRACT

Background. In research on the subject, the predictive importance of personal resources is indicated for diet quality.

Objective. The aim of the study was quantitative assessment of diet depending on the level of generalised self-efficacy among elite Polish basketball players.

Material and Methods. Food diaries (2 training days and 1 no training day) of 48 basketball players were analysed. Further assessed were 144 food rations based on the Diet 6.0 program, and the results were compared to the current Polish nutritional standards. The Generalised Self-Efficacy Scale (GSES) was also used. Statistical analyses were performed by estimating Spearman's rank correlation coefficients ($p < 0.05$).

Results. The share of energy from proteins, fats and carbohydrates was 18.2%, 29.4% and 52.4%, respectively. Of the mineral salts, the average diet contained: 2,107.6 mg sodium, 2,918.3 mg potassium, 736.3 mg calcium, 1,372.2 mg phosphorus, 380.1 mg magnesium, and 11.6 mg iron. Of the vitamins, the average diet contained: 1,100.3 µg of vitamin A, 5.3 µg of vitamin D, vitamin E in the amount of 8.2 mg, 78.1 mg of vitamin C, 1.1 mg vitamin B1, 1.3 mg vitamin B2, 1.9 mg of vitamin B6, 271.7 µg of vitamin B9 and 4.7 µg of vitamin B12. It was also shown that as the sense of self-efficacy developed, the supply of energy, water, protein, digestible carbohydrates, energy from carbohydrates, sucrose and PUFAs also increased in the players' diets. At the same time, along with the increase in self-efficacy, the supply of: Na, K, Ca, Mg, P, Fe, Cu and iodine as well as vitamins: A, E, B1, B3, B6 and C, also increased in the players' diets.

Conclusions. Incomplete diet balance has been demonstrated, as well as significant relationships between the level of self-efficacy and the supply of certain nutrients in the diet of elite Polish basketball players. The obtained results indicate the legitimacy of diet monitoring and nutritional education as well as considering personality traits in activities promoting maintaining a proper diet among athletes.

Key words: *athletes basketball training, sense of self-efficacy, quantitative nutrition evaluation*

STRESZCZENIE

Wprowadzenie. Badania wskazują na predykcyjne znaczenie zasobów osobistych dla jakości diety, która jest jednym z czynników warunkujących sukces sportowy.

Cel. Celem badań była ilościowa ocena sposobu żywienia w zależności od poziomu własnej uogólnionej skuteczności elitarnych polskich koszykarzy.

Material i metody. Analizie poddano dzienniczki żywieniowe (2 dni treningowe i 1 beztreningowy) 48 koszykarzy. W oparciu o program Dieta 6.0 oceniono 144 racje pokarmowe, a wyniki odniesiono do aktualnych norm polskich żywieniowych. Zastosowano także Skalę Uogólnionej Własnej Skuteczności (GSES). Analizy statystyczne przeprowadzono szacując współczynniki korelacji rangowych Spearmana ($p < 0,05$).

Wyniki. Udział energii z białek, tłuszczów i węglowodanów wynosił odpowiednio: 18,2%, 29,4% i 52,4%. Spośród soli mineralnych, przeciętna dieta zawierała: 2107,6 mg sodu, 2918,3 mg potasu, 736,3 mg wapnia, 1372,2 mg fosforu, 380,1 mg magnezu i 11,6 mg żelaza. Spośród witamin, przeciętna dieta zawierała: 1100,3 µg witaminy A, 5,3 µg witaminy D, 8,2 mg witaminy E, 78,1 mg witaminy C, 1,1 mg witaminy B1, 1,3 mg witaminy B2, 1,9 mg witaminy B6, 271,7 µg witaminy B9 i 4,7 µg witaminy B12. Wykazano ponadto, że wraz z nasianiem się poczucia samoskuteczności, w diecie zawodników zwiększała się podaż energii, wody, białka, węglowodanów przyswajalnych, energii z węglowodanów ($p < 0,001$) oraz sacharozy ($p = 0,021$) i PUFA ($p = 0,017$). Zarazem wraz z nasilaniem się poczucia samoskuteczności, w diecie koszykarzy zwiększała się podaż sodu ($p = 0,042$), potasu ($p < 0,001$), wapnia ($p = 0,045$), magnezu ($p = 0,007$), fosforu ($p = 0,026$), żelaza ($p = 0,013$), miedzi ($p < 0,001$) i jodu ($p = 0,042$) oraz witamin: A ($p = 0,002$), E ($p = 0,034$), B1 ($p < 0,001$), B3 ($p < 0,001$), B6 ($p < 0,001$) i C ($p = 0,049$).

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Wnioski. Wykazano niepełne zbilansowanie diety oraz istotne zależności pomiędzy poziomem poczucia własnej uogólnionej skuteczności a podażą niektórych składników pokarmowych w diecie elitarnych polskich koszykarzy. Wskazuje to na zasadność monitoringu diety i edukacji żywieniowej oraz uwzględnianie cech osobowości w oddziaływaniach promujących prawidłowy sposób żywienia sportowców.

Słowa kluczowe: *sportowcy trenujący koszykówkę, poczucie samoskuteczności, ilościowa ocena sposobu żywienia*

INTRODUCTION

The sporting success of basketball players is conditioned by a wide range of motor and mental abilities [3, 15]. Basketball players undertake high-intensity efforts, usually with short intervals for post-exercise regeneration [3, 14, 21]. In the energy of exercise in team sports (including basketball), in connection with the “stop-and-go” game model, it is particularly important to increase carbohydrate reserves before exercise, ensure their replenishment during exercise and effective re-synthesis of glycogen in the liver and muscles during recovery following exertion [23]. Therefore, achieving certain goals in sports requires special care for a varied and well-balanced diet. A diet that takes into account the increased demand for energy, fluids and some nutrients (carbohydrates, proteins, B vitamins, antioxidants and minerals) is one of the key factors contributing to the improvement of exercise capacity and the effective post-exercise recovery of athletes [13, 20].

The diet of athletes is determined by various individual factors, including psychological ones [2, 17]. One of the significant factors is the sense of self-efficacy, a defined personal resource, related to the belief in the ability to achieve intended goals, including health and nutritional ones [12]. Within this context, research allowing to confirm the predictive nature of personal resources for the quality of the nutritional behaviour among athletes, including those training team sports, can be cited [5-7].

As indicated by various authors, the subject of basketball players' diet has not been exploited in research [16, 22]. The available studies concern nutritional behaviour, and therefore, the qualitative aspects of a diet [7]. In order to present the quality of the basketball players' diet more fully, research was undertaken on the quantitative assessment of the diet and its selected individual conditions. In this regard, the sense of self-efficacy factor was adopted due to its predictive importance for the quality of the diet of athletes [6]. The research was undertaken in the belief that the obtained results, apart from cognitive value, may also have applicative importance and contribute to the individualisation of educational impact and the improvement of the effects in sports training of basketball players.

The aim of the research was to quantify the diet depending on the level of generalised sense of self-efficacy in a group of elite Polish basketball players.

MATERIAL AND METHODS

Research was conducted in a group of 48 men - Polish athletes practicing basketball professionally. The basic selection of criteria for inclusion in the study group was practicing sports at a competitive level, at the level of the highest league in Poland, for at least 3 years. The research was conducted among 8 basketball clubs. The mean age of the participants was 26.6 years (± 4.5), and the average sports experience was 8.6 years (± 4.8). The average level of BMI was 24.3 kg/m² (± 0.9).

Nutrition was assessed by the method of current recording on the basis of food diaries kept for 3 days (2 training and 1 non-training day). Therefore, 144 athletes' daily food rations were evaluated. Energy intake, as well as macronutrients and regulating ingredients (vitamins and minerals), was assessed using the Diet 6.0 nutritional program. The content of nutrients was tested in relation to the current Polish nutritional standards for men aged 19-30 [11]. The following standards were adopted for the assessment of nutrition at the level of: EAR (Estimated Average Requirement) or AI (Adequate Intake) and reference numbers for the share of individual macronutrients in the energy pool of food rations [11]. The results, in line with the methodology, were interpreted as the percentage of subjects meeting the standard of demand for individual nutrients.

Self-efficacy was measured using the Generalised Self Efficacy Scale (GSES) [12]. The GSES scores were within the range of 10-40 points (the higher the score, the higher the sense of generalised self-efficacy). The values on the GSES scale for the studied basketball players were: 30.4 (± 2.7), Me=31.0 (within the 24.0-32.0 range).

Statistical analyses were performed using the PQStat 1.8.2.182 statistical package. The correlations between the scales were analysed by estimating *Spearman's* rank correlation coefficients. The test probability at a level of $p < 0.05$ was assumed as statistically significant while probability at the level of $p < 0.01$ was considered highly significant.

RESULTS

The average daily food rations of elite Polish basketball players contained: 1,795.5 kcal, 79.3 g of protein, 58.5 g of fat, 258.2 g of total carbohydrates and 21.7 g of dietary fibre. The share of energy from proteins, fats and carbohydrates was 18.2%, 29.43%

and 52.5%, respectively. The mean water consumption was 1,682.8 ml/day. The supply of analysed nutrients is presented in Table 1.

Quantitative assessment of the basketball players' diet compared to the Polish standards allowed to show that almost all athletes met the reference values in terms of energy share from proteins and fats (95.8%

Table 1. Supply of water, energy, macronutrients, vitamins and mineral salts in the diet of Polish elite basketball players (descriptive statistics) compared to Polish nutritional standards for men aged 19-30

Variables	M	SD	Norms	% of realising participants
Energy (kcal)	1795.5	547.9	3350***	8.33
Water (g)	1682.8	713.8	2500**	18.0
Total protein (g)	79.3	23.4	-	-
Animal protein (g)	49.6	14.3	-	-
Plant protein (g)	28.7	15.8	-	-
Energy from protein (%)	18.2	3.0	10-20	95.8
Total fat	58.5	24.5	-	-
Energy from fats (%)	29.4	9.4	20-35	95.8
Saturated fatty acids (g)	17.1	7.8	-	-
MUFA (g)	23.6	12.6	-	-
PUFA (g)	12.3	6.5	-	-
Cholesterol (mg)	315.5	142.1	<300 mg	58.3
Total carbohydrates (g)	258.2	105.9	-	-
Assimilated carbohydrates (g)	234.7	92.9	-	-
Saccharose (g)	38.4	20.8	-	-
Energy from carbohydrates (%)	52.4	9.2	45-65	83.3
Fibre (g)	21.7	16.5	>25 g**	22.9
Sodium (mg)	2107.6	930.9	1500**	50.0
Potassium (mg)	2918.3	1285.5	3500**	32.6
Calcium (mg)	736.3	358.6	800*	34.7
Phosphorus (mg)	1372.2	571.5	580*	100.0
Magnesium (mg)	380.1	207.0	330*	46.5
Iron (mg)	11.6	5.2	6*	95.8
Zinc (mg)	11.1	3.7	9.4*	77.2
Copper (mg)	0.9	0.4	0.7*	56.2
Manganese (mg)	5.9	3.5	2.3**	95.8
Iodine (µg)	24.6	28.1	95*	25.9
Vitamin A (µg)	1100.3	1033.9	630*	63.9
Vitamin D (µg)	5.3	7.1	15**	11.8
Vitamin E (mg)	8.2	4.6	10**	37.5
Vitamin B1 (mg)	1.1	0.5	1.1*	40.3
Vitamin B2 (mg)	1.3	0.2	1.1*	71.5
Vitamin B3 (mg)	17.8	8.4	12*	80.5
Vitamin B6 (mg)	1.9	0.9	1.1*	90.3
Vitamin B9 (µg)	271.1	105.8	320*	25.7
Vitamin B12 (µg)	4.7	3.3	2.0*	87.5
Vitamin C (mg)	78.1	57.6	75*	50.0

*EAR, **AI, ***EER [11]

of the subjects), and the vast majority also in terms of the share of carbohydrates (83.3% of the participants). A smaller percentage of the athletes consumed 2,500 ml of fluids (18% of the respondents), cholesterol up to 300 mg a day (58.3% of the subjects) and fibre in the amount of at least 25 g per day (22.9% of the athletes). Among the assessed mineral salts, athletes met the needs for phosphorus (100%) and iron and manganese (95.8%) in the greatest percentage, while in the smallest percentage, the norms for iodine (25.9% of respondents), potassium (32.6% of subjects) in the smallest percentage of respondents, calcium (34.7% of respondents) and magnesium (46.5% of subjects) were met. Among the assessed vitamins, athletes met the requirements for vitamin B6 (90.3%) and B12 (87.5%) in the highest percentage, and in the smallest percentage, for vitamin D (11.8% of the subjects), folates (25.7%), vitamin E (37.5%), B1 (40.3%) and C (50%) (Tab. 1).

Assessment of the relationship between the content of water and nutrients in the diet and the level of GSES among the studied basketball players showed that as the level of self-efficacy of the players increased, so did the supply of energy, water, total protein, vegetable protein, total carbohydrates, assimilated carbohydrates and energy from carbohydrates ($p < 0.001$), as well as the supply of sucrose ($p = 0.021$) and PUFAs ($p = 0.017$). At the same time, the share of energy from fat decreased ($p < 0.001$). Furthermore, there was also an increase in the supply of vitamins and minerals with the increase in self-efficacy. These included: sodium ($p = 0.042$), potassium ($p < 0.001$), calcium ($p = 0.045$), magnesium ($p = 0.007$), phosphorus ($p = 0.026$) and iron ($p = 0.013$), as well as copper ($p < 0.001$) and iodine ($p = 0.042$), and vitamins A ($p = 0.002$), E ($p = 0.034$), B1 ($p < 0.001$), B3 ($p < 0.001$), B6 ($p < 0.001$) and C ($p = 0.049$) (Tab. 2).

DISCUSSION

In the discussed research, partial imbalance was indicated for the diet and correlation between the consumption of certain nutrients and the level of self-efficacy among elite Polish basketball players.

Positive nutritional trends concerned the correct share of energy from basic nutrients, higher consumption of wholesome than non-wholesome protein, and the highest share of monounsaturated fatty acids (MUFAs) in the total fatty acid structure. The dietary imbalances particularly concerned the insufficient supply of energy, water and dietary fibre as well as some vitamins (especially D, E and folic acid) and mineral salts (especially potassium, calcium and iodine). The percentage of athletes covering the daily requirement for vitamins B1 and C and magnesium was also low.

Table 2. Correlations between the supply of water, energy, macronutrients, vitamins and minerals in the diet of basketball players and the level of self-efficacy (GSES) among elite Polish basketball players (*Spearman's* monotonic correlations)

VARIABLES	GSES	
	R	<i>p</i>
Energy (kcal)	0.3701	<0.001
Water (g)	0.346	<0.001
Total protein (g)	0.292	<0.001
Animal protein (g)	0.074	0.409
Plant protein (g)	0.402	<0.001
Energy from protein (%)	-0.035	0.697
Total fat	-0.045	0.614
Energy from fat (%)	-0.297	<0.001
Saturated fatty acids (g)	-0.128	0.154
MUFA (g)	-0.128	0.154
PUFA (g)	0.212	0.017
Cholesterol (mg)	-0.103	0.251
Total carbohydrates (g)	0.373	<0.001
Assimilated carbohydrates (g)	0.406	<0.001
Saccharose (g)	0.206	0.021
Energy from carbohydrates (%)	0.377	<0.001
Fibre (g)	-0.023	0.801
Sodium (mg)	0.181	0.042
Potassium (mg)	0.375	<0.001
Calcium (mg)	0.179	0.045
Phosphorus (mg)	0.198	0.026
Magnesium (mg)	0.239	0.007
Iron (mg)	0.220	0.013
Zinc (mg)	0.140	0.118
Copper (mg)	0.547	<0.001
Manganese (mg)	0.043	0.630
Iodine (µg)	0.181	0.042
Vitamin A (µg)	0.276	0.002
Vitamin D (µg)	0.113	0.206
Vitamin E (mg)	0.189	0.034
Vitamin B1 (mg)	0.565	<0.001
Vitamin B2 (mg)	0.134	0.123
Vitamin B3 (mg)	0.416	<0.001
Vitamin B6 (mg)	0.527	<0.001
Vitamin B9 (µg)	0.072	0.422
Vitamin B12 (µg)	0.037	0.680
Vitamin C (mg)	0.175	0.049

The described deficit energy and water consumption among athletes is significant in the context of exercise physiology and the increased demand for these components. Energy and fluid deficiencies may significantly reduce exercise capacity and increase

health risks, including those related to dehydration (e.g. hyperthermia). In view of the identified nutritional deficiencies, one should also point to the pleiotropic functions of vitamin D, the antioxidant properties of vitamins E and C, the hematopoietic role of folic acid and the metabolic function of vitamin B1 (e.g. regulation of carbohydrate metabolism). Within the context of the identified nutritional deficiencies, the participation of calcium, magnesium and potassium in the contractile function of skeletal muscles should also be indicated, as well as important aspects of physical exercise physiology, therefore, factors determining exercise capacity [13, 20].

Studies by other authors from various research centres also allowed to confirm numerous quantitative and qualitative irregularities among people training basketball (competitive and amateur). The insufficient water consumption found in our own research corresponds to the results of research among amateur basketball players aged 19-29, in whom fluids were properly replenished by approx. 55%, 74% and 77%, 76.5% athletes (respectively: before, during and after training) [1]. Among the studied Polish elite male basketball players, the correct share of carbohydrates and protein in the energy pool of the diet was described, while among women from the university basketball team, insufficient consumption of carbohydrates and protein was described [24]. Carbohydrate deficiency and excess fat have also been reported among elite Spanish wheelchair basketball players [4]. The trends described in the authors' own research are also supported by the results obtained among the Spanish elite basketball players in wheelchairs, who exhibited sufficient consumption of 5 B vitamins, phosphorus, selenium and iron, and a deficient supply of vitamin E (51% of the norm) and calcium (73% of the norm) [9]. The insufficient intake of vitamin D described in our own research corresponds to the results of studies among elite professional Spanish basketball players, which confirmed that 57% of subjects had too low levels of the vitamin D-25(OH)D metabolite in the blood during the winter period (<50 nmol/L). Vitamin D intake was also too low (3.47 µg/day). It was additionally shown that the serum 25(OH)D level was significantly correlated with the intake of vitamin D ($r=0.65$; $p=0.001$) and calcium ($r=0.82$; $p<0.001$) [8]. The low magnesium supply described in our current study was also demonstrated in the elite group of basketball, handball and volleyball players. Meanwhile, magnesium is associated with muscle strength, which may be due to its role in energy metabolism, transport across cell membranes, and in muscle contraction and relaxation [19]. The described quantitative irregularities in the diet of elite Polish basketball players correspond to the qualitative irregularities shown in studies carried out by various

authors. And thus, among Polish basketball players, a low frequency of consumption of vegetables and fruit as well as fermented dairy products was described [7], which corresponds to a low supply of folates, vitamin C and potassium, magnesium and calcium in the discussed research. Also, among Greek basketball players, a low consumption of vegetables and grain products on training days was described [22].

The significant correlations between the level of self-efficacy and the consumption of nutrients indicated in the discussed research concerned the increase in the supply of energy, water, protein (including vegetable), assimilated carbohydrates (and sucrose), polyunsaturated fatty acids (PUFA) and energy from carbohydrates, and decreasing people energy from fats in food rations. Positive relationships were also found between the level of self-efficacy and the supply of antioxidant vitamins (A, E, C) and B vitamins (B1, B3, B6) as well as mineral salts (Na, K, Ca, P, Mg, Fe, Cu, I). The found dependencies generally confirm the tendency towards a greater supply of essential ingredients in the diet, with significant functional properties in conditions of vigorous physical effort, including those related to the energy of physical exertion, hydration, supply of building-block and energy substances, increasing the antioxidant potential, regulating the proper course of metabolic processes, water-electrolyte, acid-base and haematopoietic processes [13, 20].

The tendency towards a more balanced diet in basketball players with higher self-efficacy confirms their greater care for the quality of the diet as one of the key factors of sports success, thus fitting into the characteristics of this personality dimension. The tendency to make more intense rational nutritional choices among team sports athletes along with an increasing sense of self-efficacy has also been confirmed in other studies. Other trials conducted among Polish basketball players confirmed the tendency towards a larger scale of rational behaviour, including the consumption of vegetables and fruit, whole grain cereal products and fish, along with an increasing sense of self-efficacy [7]. The tendency for more rational choices related to the reduction of trans isomers and simple sugars in the diet among athletes with higher self-efficacy has been confirmed in meta-analysis research [10].

The obtained results, indicating incomplete balance of the diet of elite Polish basketball players and significant relationships between the quality of the diet (in the quantitative dimension) and the level of self-efficacy, confirm the legitimacy of further monitoring diet and nutritional education, and taking into account personality traits in activities promoting the proper nutrition of athletes, as indicated by others authors [7, 9, 24]. Meta-analytical studies have allowed

to confirm that nutritional education of team sports athletes can be an effective strategy for improving their eating habits, nutritional knowledge and body composition [18].

CONCLUSIONS

Quantitative assessment of the diet allowed to show incomplete balance in the diet of elite Polish basketball players, with an indication of an insufficient supply of energy, water and dietary fibre as well as some vitamins (especially D, E and folic acid) and mineral salts (especially potassium, calcium and iodine). The percentage of athletes covering the daily requirement for vitamins B1 and C and magnesium was also low.

Significant correlations have been demonstrated between the level of self-efficacy and the consumption of nutrients in one's diet, showing a tendency towards a greater supply of ingredients with important functional properties under conditions of vigorous physical exercise, including energy, water, protein, assimilated carbohydrates and PUFAs, as well as some vitamins (antioxidants and group B) and mineral salts (Na, K, Ca, P, Mg, Fe, Cu, I) in basketball players with a higher level of self-efficacy.

The obtained results indicate the legitimacy of diet monitoring and nutritional education as well as considering personality traits in activities promoting maintaining a proper diet among athletes.

Conflict of interest

None declared.

REFERENCES

1. *Bibiloni M.M., Vidal-Garcia E., Carrasco M., Julibert A., Pons A., Tur Mari JA.*: Hydration habits before, during and after training and competition days among amateur basketball players. *Nutr Hosp* 2018;35(3):612-619. doi: 10.20960/nh.1462.
2. *Birkenhead K.L., Slater G.*: A review of factors influencing athletes' food choices. *Sports Med* 2015;45(11):1511-1522. doi: 10.1007/s40279-015-0372-1.
3. *Calleja-González J., Terrados N., Mielgo-Ayuso J., Delextrat A., Jukic I., Vaquera A., Torres L., Schelling X., Stojanovic M., Ostojic S.M.*: Evidence-based post-exercise recovery strategies in basketball. *Phys Sportsmed* 2016;44(1):74-78. doi: 10.1080/00913847.2016.1102033.
4. *Ferro A., Garrido G., Villacieros J., Pérez J., Grams L.*: Nutritional Habits and Performance in Male Elite Wheelchair Basketball Players During a Precompetitive Period. *Ad Phys Activ Quarterly* 2020;34(3): 295-310. doi: 10.1123/apaq.2016-0057.
5. *Gacek M.*: Association between self-efficacy and dietary behaviors of American football players in the Polish clubs in the light of dietary recommendations for athletes. *Rocz Panstw Zakl Hig* 2015;66(4): 361-366.
6. *Gacek M.*: Selected Individual Determinants of Nutritional Behaviours among Athletes Performing Team Sports. *Hygeia Public Health* 2019;54(4): 243-250.
7. *Gacek M., Wojtowicz A.*: Personal resources and nutritional behavior of Polish basketball players. *J Phys Edu Sport* 2021; 1:140-139. DOI:10.7752/jpes.2021.01018.
8. *García R.B., Guisado F.A.R.*: Low levels of vitamin D in professional basketball players after wintertime: relationship with dietary intake of vitamin D and calcium. *Nutr Hosp* 2011;26(5): 945-951. doi: 10.1590/S0212-161.
9. *Grams L., Garrido G., Villacieros J., Ferro A.*: Marginal Micronutrient Intake in High-Performance Male Wheelchair Basketball Players: A Dietary Evaluation and the Effects of Nutritional Advice. *PLoS One* 2016;11(7): e0157931. doi: 10.1371/journal.pone.0157931.
10. *Imamura F., Micha R., Wu J.H.Y., de Oliveira Otto M.C., Otite F.O., Abioye A.I., Mozaffarian D.*: Effects of Saturated Fat, Polyunsaturated Fat, Monounsaturated Fat, and Carbohydrate on Glucose-Insulin Homeostasis: A Systematic Review and Meta-analysis of Randomised Controlled Feeding Trials. *PLoS Medicine* 2016; 13(7): e1002087. doi: 10.1371/journal.pmed.1002087.
11. *Jarosz M., Rychlik E., Stoś K., Charzewska J.*: Normy żywienia dla populacji Polski i ich zastosowanie [Nutritional Norms for the Polish Population and their Application]. NIZP-PZH, Warszawa 2020 (In Polish)
12. *Juczyński Z.*: Narzędzia pomiaru w promocji i psychologii zdrowia [Measurement tools in promotion and health psychology]. Pracownia Testów Psychologicznych, Warszawa 2012. (In Polish)
13. *Kerksick C.M., Wilborn C.D., Roberts M.D., Smith-Ryan A., Kleiner S.M., Jäger R., Collins R., Cooke M., Davis J.N., Galvan E., Greenwood M., Lowery L.M., Wildman R., Antonio J., Kreider R.B.*: ISSN exercise & sports nutrition review update: Research & recommendations. *J Int Soc Sports Nutr* 2018;15(38). <https://doi.org/10.1186/s12970-018-0242-y>.
14. *Kostopoulos N., Apostolidis N., Mexis D., Mikellidi A., Nomikos T.*: Dietary intake and the markers of muscle damage in elite basketball players after a basketball match. *J Phys Edu Sport* 2017;17(1): 394. DOI:10.7752/jpes.2017.01058.
15. *Koutsouridis C., Lioutas D., Galazoulas C., Karamousalidis G., Stavropoulos N.*: Effect of offensive rebound on the game outcome during the 2019 Basketball World Cup. *J Phys Edu Sport* 2020;20(6): 3651-3659. DOI:10.7752/jpes.2020.06492.
16. *Ott E.I., Santos J.I.*: The role of nutrition in the recovery of a basketball player. *Nutr Hosp* 2020; 37(1):160-168. doi: 10.20960/nh.02577.
17. *Pelly F.E., Burkhart S.J., Dunn P.*: Factors influencing food choice of athletes at international competition events. *Appetite* 2018;121:173-178. doi: 10.1016/j.appet.2017.11.086.
18. *Sánchez-Díaz S., Yanci J., Castillo D., Scanlan A.T., Raya-González J.*: Effects of Nutrition Education

- Interventions in Team Sport Players. A Systematic Review. *Nutrients* 2020;12(12): 3664. doi: 10.3390/nu12123664.
19. Santos D.A., Matias C., Monteiro C.P., Silva M., Rocha P.M., Minderico C.S., Sardinha L.B., Laires M.J.: Magnesium intake is associated with strength performance in elite basketball, handball and volleyball players. *Magnes Res* 2011;24(4):215-219. doi: 10.1684/mrh.2011.0290.
20. Thomas D.T., Erdmann K.A., Burke L.M.: Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. *J Acad Nutr Diet* 2016;116(3): 501-528. doi: 10.1016/j.jand.2015.12.006.
21. Tokatlidou C., Xirouchaki C.E., Armenis E., Apostolidis, N.: Hematologic, biochemical, and physiologic characteristics of elite and professional basketball players. *J Phys Edu Sport* 2020; 20(6):3384-3390. DOI:10.7752/jpes.2020.06458.
22. Tsoufi A., Maraki M.I., Dimitrakopoulos L., Famisis K., Grammatikopoulou M.G.: The effect of professional dietary counseling: elite basketball players eat healthier during competition days. *J Sports Med Phys Fitness* 2017;57(10):1305-1310. doi: 10.23736/S0022-4707.16.06469-0.
23. Williams C., Rollo I.: Carbohydrate Nutrition and Team Sport Performance. *Sports Med* 2015; 45(Suppl 1):13-22. doi: 10.1007/s40279-015-0399-3.
24. Zanders B.R., Currier B.S., Harty P.S., Zabriskie H.A., Smith C.R., Stecker R.A., Richmond S.R., Jagim A.R., Kerksick C.M.: Changes in Energy Expenditure, Dietary Intake, and Energy Availability Across an Entire Collegiate Women's Basketball Season. *J Strength Cond Res* 2021;35(3):804-810. doi: 10.1519/JSC.0000000000002783.

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DIAGNOSIS OF OBESITY AND EVALUATION OF THE RISK OF PREMATURE DEATH (ABSI) BASED ON BODY MASS INDEX AND VISCERAL FAT AREA

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ABSTRACT

Background. Body mass index (BMI) is the most commonly used parameter for identifying obesity. However, it is a tool that can distort the diagnosis as misdiagnose.

Objective. The aim of the study was to evaluate the BMI and visceral fat area (VFA) and to determine the presence of obesity in a group of young people and to assess their suitability for use together with other parameters indicating excessive body fat and increased risk of non-communicable disease and premature death.

Material and Methods. The study group consisted of 339 university students. We used InBody 720 for diagnosis body composition. The following body composition parameters were measured – BMI, waist circumference (WC), fat-free mass (FFM), VFA, percentage of body fat (PBF).

Results. The BMI values by gender indicate overweight in the male group compared to females (25.2 ± 3.1 and 22.2 ± 3.4 kg.m⁻², respectively; $p < 0.001$). Women had higher values of VFA than men (70.1 ± 26.4 and 56.2 ± 28.3 cm², respectively; $p < 0.001$). Although the group of men had an increased average BMI, which allows us to talk about overweight, the risk of premature death was low. In the case of the male group, a high proportion of fat-free mass had a major impact on BMI. Lower values of fat parameters also contributed to the low risk of premature death. We found a nonlinear relationship in the BMI assessment in terms of premature risk of death. Higher values of the premature death risk were found in the subgroups of underweight and obesity. In the case of the VFA and ABSI relationship a linear increase in the curve and the risk of premature death was observed.

Conclusions. In order to evaluate the presence of overweight or obesity it is necessary to use not only BMI but other diagnostic elements for this purpose. The components of the body composition need to be evaluated comprehensively. Evidence of this is the risk of premature death, where optimal BMI values may pose an increased risk and vice versa.

Key words: *body mass index, visceral fat area, obesity, ABSI, premature death*

INTRODUCTION

Lifestyle changes contribute to the increasing incidence of obesity and factors that increase weight include, in particular, a sedentary lifestyle, unhealthy diet and physical inactivity [1]. Corder et al. [2] in their meta-analysis showed a decrease in physical activity from the period of adolescence to young adulthood by 13-17%. According to da Silva et al. [3] in people who performed physical activity for more than 300 minutes per week, the incidence of obesity was lower compared to the inactive. Those who performed higher intensity activities had a significant protective factor against obesity. Svozilová et al. [4] found out the significant

associations between adiposity and physical activity and sedentary behaviour patterns even in older women.

Overweight and obesity are complex states of multifactorial origin. Obesity is the result of a violation of energy balance by too many calories consumed and their too low expenditure [5]. Obesity poses a major threat to public health because its prevalence increases very rapidly and has a significant impact on health harm and poor quality of life [6]. It can cause and/or worsen a wide range of concomitant diseases such as cardiovascular disease, type 2 diabetes mellitus, and also increase the risk of developing certain cancers, leading to increased morbidity and mortality [7, 8, 9].

Analysis of body composition is a very important part of the evaluation of the state of nutrition in

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humans and helps to determine the basic nutritional state and diagnose obesity, assess the state of health and the risk of the disease [10]. The composition of the body can be measured in several ways. Anthropometric measurements are an effective and non-invasive method of measuring the composition of the body. Currently, in epidemiology, clinical nutrition and research, body mass index is most often used for the usual characteristics of the state of weight for ease of measurement. However, body mass index is a weak and indirect measure of body composition, because it can be increased due to higher fat mass, but also due to muscle mass [11]. It provides only approximate information on body composition without distinguishing between fat mass and muscle mass. This deficiency can lead to incorrect classification of healthy people [12]. Likewise, body mass index does not distinguish between visceral fat and subcutaneous fat. Individuals with excessive amounts of visceral fat and ectopic fat have a higher cardiometabolic risk [13]. Therefore, central obesity indices could be more reliable indicators of adiposity. Having a larger waist circumference, even within the normal BMI range, is associated with cardiometabolic abnormalities [14] and a higher risk of mortality and morbidity [15, 16]. Aune et al. [17] found that abdominal obesity, an increase in waist circumference of 10 cm, led to an increased incidence of heart failure. As a result of these deficiencies, other and newer indicators and variables such as visceral fat or a body shape index for more accurate diagnosis of obesity and mortality estimate are gradually included [18].

The aim of the work was to evaluate the body mass index and visceral fat area and to determine the presence of obesity in a selected group of young people and to assess their suitability for use together with other parameters indicating excessive body fat and increased risk of non-communicable disease and premature death.

MATERIALS AND METHODS

Characteristics of the study group

The study group consisted of 339 university students of the Human Nutrition study program (254 women, age 18-24 years and 85 men, age 18-24 years) with average age 21 ± 2 years. The basic characteristics of the group are given in Table 1. The participant's group consisted of healthy young adults.

Anthropometric measurements

We used InBody 720 (Biospace Co. Ltd., Seoul, Republic of Korea) for diagnosis body composition. Participants were informed about the measurement procedure before the start of the measurement and they were also emphasized information and warnings

about the possible risks arising from the measurement if they have an electrical device implanted in their body on the heart or in case of pregnancy. Before the measurement, participants were asked to eliminate and refrain from drinking large amounts of water and all participants signed an informed written consent as well as consent to the processing of personal data. Lookin'Body 3.0 software was used to process the results. The following body composition parameters were measured – body mass index (BMI, $\text{kg}\cdot\text{m}^{-2}$), waist circumference (WC, cm), fat-free mass (FFM, %), visceral fat area (VFA, cm^2), percentage of body fat (PBF, %). The body height of the participants was measured by using a stadiometer with an accuracy of 0.1 cm. The participant stood upright on a horizontal surface, barefoot, with palms turned inwards and fingers pointing downwards. The head was in horizontal plane. The height was measured from the sole of the feet to the top of the head. Body weight, body mass index, waist circumference, visceral fat area, percentage of body fat and fat-free mass were determined directly by InBody 720. The risk of premature death (ABSI z-score) was calculated according to the methodology of *Krakauer* and *Krakauer* [19]. Participants were assessed as obese if the BMI values were $\geq 30 \text{ kg}\cdot\text{m}^{-2}$, waist circumference ≥ 88 cm and ≥ 102 cm, for women and men, respectively [20], visceral fat area $\geq 100 \text{ cm}^2$ and body fat percentage values $\geq 28\%$ for women and for men $\geq 20\%$ according to [21].

Statistical analysis

We used Microsoft Office Excel 2016 (Los Angeles, CA, USA) in combination with XLSTAT (Version 2019) to process data and STATISTICA Cz version 13 (TIBCO Software Inc., Palo Alto, California, USA) for statistical analysis. We present the basic statistical characteristics as mean, \pm SD (standard deviation), max (maximum) and min (minimum). Levels of statistical significance were determined at $p < 0.05$. With a one-factor variance analysis (ANOVA), we tested the differences between anthropometric data and compared using Post Hoc Test.

RESULTS

After a comprehensive evaluation of the study group, we can conclude that in terms of assessing the average BMI and VFA values, the research sample of participants was not included in the category of obesity (Table 1). Based on somatic and biological assumptions and expected differences in terms of gender, we evaluated groups of men and women separately. As expected, differences in key parameters between the genders were significant. The mean BMI values by gender indicate overweight in the male group compared to females (25.2 ± 3.1 and 22.2 ± 3.4

Table 1. Descriptive characteristics of study group (n = 339)

Parameters – all participants (n=339)	Mean	± SD	Max	Min	P – value
Age, years	21	2	24	18	= 0.59
Height, cm	171	8	195	151	< 0.001
Weight, kg	67.2	13.5	116	43	< 0.001
Body mass index, kg.m ²	23.0	3.5	38.8	16.8	< 0.001
Waist circumference, cm	82.0	9.6	119.3	65.6	< 0.001
Fat-free mass, %	75.5	8.2	97.0	50.7	< 0.001
Visceral fat area, cm ²	66.6	27.5	171.1	5.0	< 0.001
Percentage of body fat, %	24.5	8.2	49.3	3.0	< 0.001
ABSI z-score (premature death risk)	0.1032	0.8887	2.3669	-2.7106	< 0.001
Female (n=254)	Mean	± SD	Max	Min	
Age, years	21	2	24	18	
Height, cm	167	6	189	151	
Weight, kg	62.4	10.5	116	43	
Body mass index, kg.m ²	22.2	3.4	38.8	16.8	
Waist circumference, cm	80.4	9.2	119.3	65.6	
Fat-free mass, %	72.8	6.9	88.1	50.7	
Visceral fat area, cm ²	70.1	26.4	171.1	14.3	
Percentage of body fat, %	27.2	6.9	49.3	12.0	
ABSI z-score (premature death risk)	0.3004	0.7360	2.3669	-1.6175	
Male (n=85)	Mean	± SD	Max	Min	
Age, years	21	1	24	18	
Height, cm	180	6	195	168	
Weight, kg	81.6	11	108.7	59.6	
Body mass index, kg.m ²	25.2	3.1	32.8	19.0	
Waist circumference, cm	87.1	9.3	118.1	68.9	
Fat-free mass, %	83.9	5.8	97.0	67.8	
Visceral fat area, cm ²	56.2	28.3	147.9	5.0	
Percentage of body fat, %	16.1	5.8	32.2	3.0	
ABSI z-score (premature death risk)	-0.4846	1.0381	2.3309	-2.7106	

Note. ± SD = standard deviation; Max = maximum value; Min = minimum value

kg.m², respectively). We found a significant difference ($p < 0.001$). In the case of a VFA assessment, we found that women had higher values than men (70.1 ± 26.4 and 56.2 ± 28.3 cm², respectively, $p < 0.001$). Similarly, we recorded significant differences in other monitored parameters. Although the group of men had an increased average BMI, which allows us to talk about overweight, the risk of premature death was low. There was average risk of premature death for study group but low risk for men and high risk for women. However, in the case of BMI, it is necessary to evaluate the body composition in terms of the proportion of the muscular and fat part. In the case of the male group, a high proportion of fat-free mass had a major impact on BMI values. Lower values of fat parameters such as visceral fat area and percentage of body fat, as well as lower waist circumference values for the male category, also contributed to the low risk of premature death.

Subsequently we focused on the evaluation of the observed parameters in relation to other, equally important components of body composition. Participants were divided into individual subgroups

according to average BMI values (Table 2). As expected, the values of other parameters, with the exception of fat-free mass, also increased with increasing BMI values. In the case of FFM, we found a linear but decreasing trend of values. According to Kutáč [22] the share of fat-free mass is about 85% for men and 75-80% for women. Of the 68 people who were categorized by BMI into the overweight group, 44.12% of them had FFM 80% or more. The inclusion of these individuals in the category of overweight according to BMI may not be correct, because BMI can be increased due to higher fat-free mass. We did not observe any significant differences in PBF ($p = 0.59$) between the underweight, normal weight and overweight groups. Significant differences were found between the obese group and all other groups ($p < 0.001$). There was a linear increase in waist circumference with increasing BMI values in all categories ($p < 0.001$). Our study confirmed a linear rise in visceral fat area values. The VFA upper reference standard value was exceeded only in the obese group.

Table 2. Body mass index in relation to selected parameters and categorization of the group according to the degree of obesity in terms of BMI

BMI kg.m ⁻²	n	BMI (kg.m ⁻²)	WC (cm)	FFM (%)	VFA (cm ²)	PBF (%)	ABSI z-score
< 18,5 / underweight	18	17.87	71.33 ^a	78.5 ^a	46.5 ^a	21.51 ^a	0.73836 ^a
18,5-24,9 / normal weight	239	21.67	78.66 ^b	76.11 ^a	60.12 ^a	23.89 ^a	0.08434 ^b
25-30 / overweight	68	26.94	91.38 ^c	75.51 ^a	80.51 ^b	24.49 ^a	-0.1567 ^b
> 30 / obesity	14	32.56	108.28 ^d	62.3 ^b	136.10 ^c	37.70 ^b	0.87061 ^a

Note. n = number of participants; BMI = Body Mass Index; WC = Waist Circumference; FFM = Fat-Free Mass; VFA = Visceral Fat Area; PBF = Percentage of Body Fat; ABSI z-score = risk of premature death; ^{abcd} = different symbols in a line mean significant differences in average intergroup values

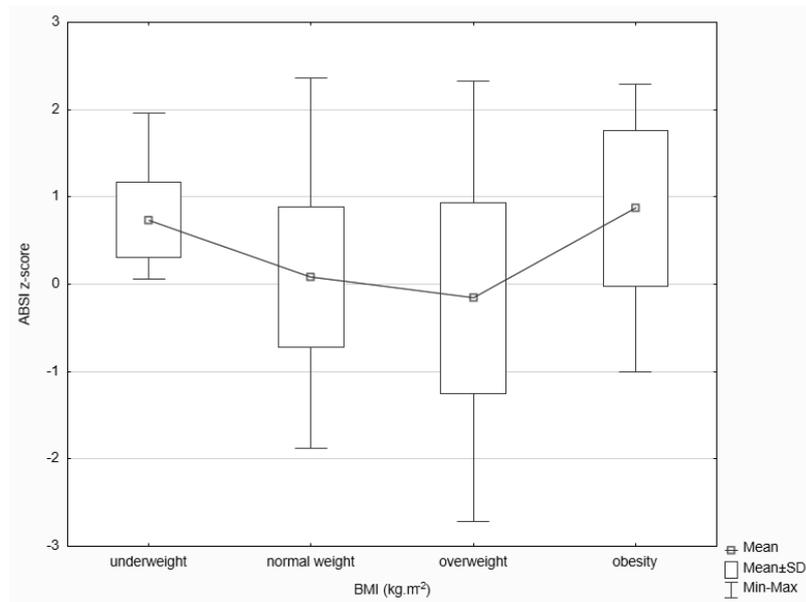


Figure 1. Box Plot of ABSI z-score grouped by BMI (kg.m⁻²)

We found a nonlinear relationship in the BMI assessment in terms of premature risk of death (Figure 1). Higher values of the premature death risk were found in the subgroups of underweight and obesity. In terms of the risk of premature death, just as *Krakauer* and *Krakauer* [19] state that at low and high BMI values there was an increase in the risk of mortality compared to medium values.

Visceral fat area is a very important element of body composition. For the health of the individual are not suitable either too low, but also not too high values of this parameter. A majority part of our study group consisted of participants with optimal or limit values of visceral fat area. We found a linear increase in the values of individual parameters with increasing VFA values, except fat-free mass, which had a decreasing curve trend. In most cases, there were significant differences (Table 3).

However, in contrast to the parabolic relationship between BMI and ABSI, we found in the case of the VFA and ABSI relationship a linear increase in the curve and the risk of premature death (Figure 2). From

this point of view, the visceral fat area seems to be a very key element in the diagnosis of obesity, but also in the assessment of the health risks associated with it.

DISCUSSION

Body mass index is the most commonly used parameter for identifying obesity. However, it is a tool that, under the influence of several factors, can distort the diagnosis as misdiagnose. In order to evaluate the presence of overweight or obesity in an individual, it is necessary to use other diagnostic elements for this purpose, such as waist circumference, the percentage of fat in the body or the proportion of visceral fat in body weight, but also the proportion of active body mass [23].

The body mass index represents only an approximate assessment of obesity, because it does not capture the proportion of fat and fat-free mass [24, 12, 25, 26]. Based on these findings, we can conclude that the application of BMI is not suitable, for example, in

Table 3. The visceral fat area in relation to selected parameters and categorization of the group according to the degree of obesity in terms of VFA

VFA (cm ²)	n	VFA (cm ²)	WC (cm)	FFM (%)	BMI (kg.m ⁻²)	PBF (%)	ABSI z-score
< 40 / low	37	27.65	75.07 ^a	87.67 ^a	21.24 ^a	12.34 ^a	-0.7587 ^a
40-70 / optimal	175	54.80	77.78 ^a	78.29 ^b	21.58 ^a	21.71 ^b	-0.0781 ^b
> 70-100 / limit	91	82.81	85.69 ^b	70.52 ^c	24.08 ^b	29.48 ^c	0.39217 ^c
> 100-130 / high	26	113.30	96.98 ^c	63.93 ^d	27.38 ^c	36.07 ^d	1.0911 ^d
> 130 / extreme	10	149.08	110.58 ^d	58.66 ^e	32.50 ^d	41.34 ^e	1.2675 ^d

Note. n = number of participants; VFA = Visceral Fat Area; BMI = Body Mass Index; WC = Waist Circumference; FFM = Fat-Free Mass; PBF = Percentage of Body Fat; ABSI z-score = risk of premature death; ^{abcde} = different symbols in a line mean significant differences in average intergroup values

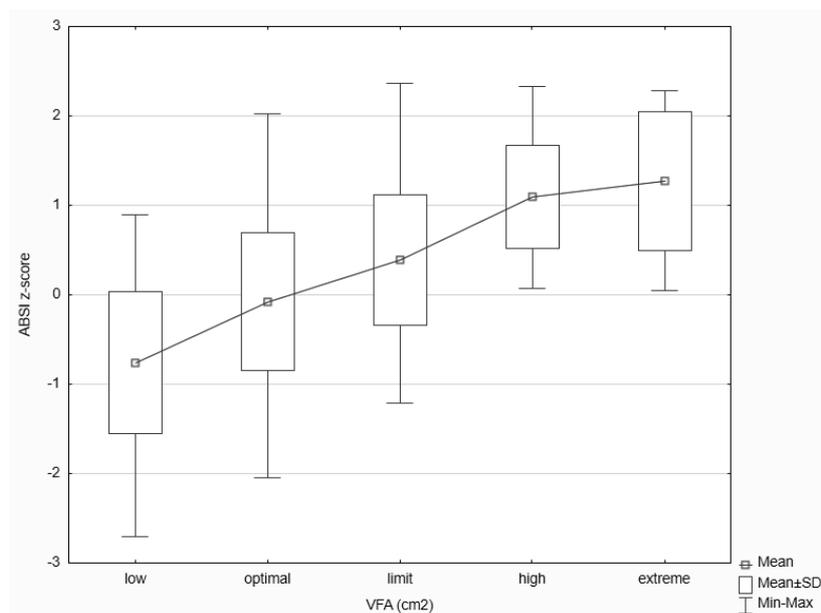


Figure 2. Box Plot of ABSI z-score grouped by VFA (cm²)

athletes or adults who have a high degree of muscle mass [27, 28, 23].

The percentage of body fat could be a more reliable and accurate indicator of general obesity and health risk compared to BMI [29]. The findings of the *Park et al.* [30] suggest that an increase in PBF was associated with a high risk of high blood pressure even in people who did not suffer from obesity.

Gierach et al. [31] found that the waist circumference was significantly correlated with BMI. Similarly, strong correlation between BMI and waist circumference was confirmed by *Sato et al.* [32]. *Aye and Szali* [33] suggest that metabolic risk factors should be detected if waist circumference exceeds 80 cm regardless of gender and regardless of BMI values, as they suggest that waist circumference is a better predictor of risk factors for developing metabolic syndrome compared to BMI. Similarly, *Bouguerra et al.* [34] concluded that waist circumference is a suitable measure of adipose tissue in the abdominal

area, which is a risk factor for diabetes and is closely related to other risk factors for cardiovascular disease. In the study by *Jacobs et al.* [35] increased waist circumference value was associated with a higher risk of mortality independently of BMI. The relative risk of death associated with a 10 cm increase in waist circumference ranged from 15% to 25% [35]. The positive association between waist circumference size and mortality in each BMI category is also confirmed by *Cerhan et al.* [36].

Visceral obesity compared to adiposity occurring in another area of the body is associated with higher metabolic morbidity and mortality due to higher levels of inflammatory processes [37]. It follows that, exceeding 100 cm² value is no longer very beneficial to health, even if BMI values would be in normal. *Zajac-Gawlak et al.* [38] showed a 12 times higher risk of metabolic syndrome in women with VFA >100 cm² than in the VFA group < 100 cm². In glucose tolerance tests, subjects with VFA >100 cm²

showed high serum triglycerides, high blood pressure and a high glucose profile [39]. The risk of mortality associated with cardiovascular disease increased at higher VFA values [40]. VFA can be considered as a good index of evaluation not only of accumulation of visceral fat, but also of cardiovascular factors [41]. The waist circumference was in the study by *Janssen et al.* [14] regardless of gender, a stronger correlate of visceral fat compared to BMI. Similarly, we could see this in our group of monitored participants, because the BMI in the group with the boundary visceral fat area was in the range of normal weight and the waist circumference already showed an increased risk for the female gender. Based on the findings of the study by *Gažarová et al.* [42], the size of VFA captures abdominal obesity and may point to an increased risk of associated diseases.

CONCLUSIONS

It is necessary to focus our attention in the routine diagnosis of obesity not only on the evaluation of BMI, but also other anthropometric parameters. Slightly elevated BMI values do not necessarily mean overweight, but it can be a significant effect of lean mass on body weight, which naturally distorts the resulting diagnosis. Attention should be focused, among other things, on visceral fat, which has a significant effect on health and metabolic processes in the body. At the same time, overweight and obesity need to be assessed from a comprehensive perspective in relation to the risk of morbidity and mortality, as well as premature death. As we confirmed in our study, mild overweight in BMI may even be inversely related to the risk of premature death, but this was not confirmed in the case of visceral fat.

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Conflict of interest

There were no conflicts of interest.

REREFENCES

1. *Kerkadi, A., Sadig, A.H., Bawadi, H., Al Thani, A.A.M., Al Chetachi, W., Akram, H., Al-Hazzaa, H.M., & Musaiger, A.O.*: The Relationship between Lifestyle Factors and Obesity Indices among Adolescents in Qatar. *Int. J Environ Res Publ Health* 2019;16(22):4428. <https://doi.org/10.3390/ijerph16224428>
2. *Corder, K., Winpenny, E., Love, R., Brown, H. E., White, M., & Sluijs, E. V.*: Change in physical activity from adolescence to early adulthood: a systematic review and meta-analysis of longitudinal cohort studies. *Br. J Sports Med.* 2019;53(8):496-503. <https://doi.org/10.1136/bjsports-2016-097330>
3. *da Silva, R. P., Del Duca, G. F., Delevatti, R. S., Streb, A. R., & Malta, D. C.*: Association between characteristics of physical activity in leisure time and obesity in Brazilians adults and elderly. *Obes Res. Clin. Pract.* 2021;15(1):37-41. <https://doi.org/10.1016/j.orcp.2020.11.004>
4. *Svozilová, Z., Pelclová, J., Pechová, J., Přidalová, M., Zajac-Gawlak, I., Thučáková, L., & Kaplanová, T.*: Associations between adiposity and physical activity and sedentary behaviour patterns in older women. *Acta Gymnica* 2019;49(2):83-91. doi: 10.5507/ag.2019.006
5. *Blüher M.*: Obesity: global epidemiology and pathogenesis. *Nature reviews. Endocrinol.* 2019;15(5):288-298. <https://doi.org/10.1038/s41574-019-0176-8>
6. *Seidell, J. C., & Halberstadt, J.*: The global burden of obesity and the challenges of prevention. *Ann Nutr Metab.* 2015;66 Suppl 2;7-12. <https://doi.org/10.1159/000375143>
7. *Parto, P., & Lavie, C. J.*: Obes Cardiovascular. *Diseases. Current problems in cardiology* 2017;42(11):376-394. <https://doi.org/10.1016/j.cpcardiol.2017.04.004>
8. *Kyrou I, Randeve H.S., Tsigos C, et al.*: Clinical Problems Caused by Obesity. 2018. In: Feingold KR, Anawalt B, Boyce A, et al., editors. *Endotext* [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000-. <https://www.ncbi.nlm.nih.gov/books/NBK278973/>
9. *Nosratzahi, S., Tasdighi, E., Hadaegh, F., Khalili, D., Mahdavi, M., & Valizadeh, M.*: Contribution of obesity in increasing type 2 diabetes prevalence in Iranian urban and rural adults during recent decade. *Primary care diabetes* 2021;15(6):1052-1057. <https://doi.org/10.1016/j.pcd.2021.07.006>
10. *Gavriilidou, N. N., Pihlsgård, M., & Elmståhl, S.*: Anthropometric reference data for elderly Swedes and its disease-related pattern. *Eur J. Clin Nutr* 2015;69(9):1066-1075. <https://doi.org/10.1038/ejcn.2015.73>
11. *Müller, M. J., Braun, W., Enderle, J., & Bosy-Westphal, A.*: Beyond BMI: Conceptual Issues Related to Overweight and Obese Patients. *Obesity facts* 2016;9(3):193-205. <https://doi.org/10.1159/000445380>
12. *Freedman, D. S., Ogden, C. L., & Kit, B. K.*: Interrelationships between BMI, skinfold thicknesses, percent body fat, and cardiovascular disease risk factors

- among U.S. children and adolescents. *BMC pediatrics* 2015;15:188. <https://doi.org/10.1186/s12887-015-0493-6>
13. *Piché, M. E., Tchernof, A., & Després, J. P.*: Obesity Phenotypes, Diabetes, and Cardiovascular Diseases. *Circulation research* 2020;126(11):1477-1500. <https://doi.org/10.1161/CIRCRESAHA.120.316101>
14. *Janssen, I., Katzmarzyk, P. T., & Ross, R.*: Body mass index, waist circumference, and health risk: evidence in support of current National Institutes of Health guidelines. *Archives of internal medicine* 2002;162(18):2074-2079. <https://doi.org/10.1001/archinte.162.18.2074>
15. *Sahakyan, K. R., Somers, V. K., Rodriguez-Escudero, J. P., Hodge, D. O., Carter, R. E., Sochor, O., Coutinho, T., Jensen, M. D., Roger, V. L., Singh, P., & Lopez-Jimenez, F.*: Normal-Weight Central Obesity: Implications for Total and Cardiovascular Mortality. *Annals Inter. Medicine* 2015;163(11):827-835. <https://doi.org/10.7326/M14-2525>
16. *Bosomworth N. J.*: Normal-weight central obesity: Unique hazard of the toxic waist. *Canadian family physician Medecin de famille canadien* 2019;65(6):399-408.
17. *Aune, D., Sen, A., Norat, T., Janszky, I., Romundstad, P., Tonstad, S., & Vatten, L. J.*: Body Mass Index, Abdominal Fatness, and Heart Failure Incidence and Mortality: A Systematic Review and Dose-Response Meta-Analysis of Prospective Studies. *Circulation* 2016;133(7):639-649. <https://doi.org/10.1161/CIRCULATIONAHA.115.016801>
18. *Veghari, G., Salehi, A., & Vaghari, M.*: The comparison of waist circumference, waist-to-hip ratio, and waist-to-height ratio among rural women adults in the North of Iran, between the years 2004 and 2013. *ARYA atherosclerosis* 2018;14(4):169-176. <https://doi.org/10.22122/arya.v14i4.1518>
19. *Krakauer, N. Y., & Krakauer, J. C.*: A new body shape index predicts mortality hazard independently of body mass index. *PloS one* 2012;7(7):e39504. <https://doi.org/10.1371/journal.pone.0039504>
20. *Rezaianzadeh, A., Namayandeh, S. M., & Sadr, S. M.*: National Cholesterol Education Program Adult Treatment Panel III Versus International Diabetic Federation Definition of Metabolic Syndrome, Which One is Associated with Diabetes Mellitus and Coronary Artery Disease?. *International journal of preventive medicine* 2012;3(8):552-558.
21. *Biospace*: InBody 720 – The precision body composition analyzer (User’s Manual). Seoul, Korea. Retrieved February 09, 2022 from: https://www.bodyanalyse.no/gammel/images/stories/inbody/dokumenter/InBody720_User_manual.pdf
22. *Kutáč, P.*: Základy kinantropometrie [Basics of kinanthropometry] (1st ed.). Ostrava: PdF Ostravské univerzity, 2009;87 pp. ISBN 978-80-7368-726-7.
23. *Gažarová, M., & Lenártová, P.*: Zmeny telesnej kompozície vplyvom konzumácie celozrnných pekárskech výrobkov [Changes in body composition due to consumption of whole grain bakery products] (1st ed.). Nitra: Slovenská poľnohospodárska univerzita v Nitre, 2020. 101 pp. ISBN 978-80-552-2283-7. In Slovak
24. *Málková, I., & Málková H.*: Obezita. Malými krůčky k velké změně [Obesity. Small steps to big change] (1st ed.). Praha: Stob, 2014. 191 pp. ISBN 978-80-87250-24-2. In Czech
25. *Javed, A., Jumean, M., Murad, M. H., Okorodudu, D., Kumar, S., Somers, V. K., Sochor, O., & Lopez-Jimenez, F.*: Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents: a systematic review and meta-analysis. *Pediatric Obes.* 2015;10(3):234-244. <https://doi.org/10.1111/ijpo.242>
26. *O'Rourke R. W.*: Adipose tissue and the physiologic underpinnings of metabolic disease. *Surgery for obesity and related diseases : official journal of the American Society for Bariatric Surgery* 2018;14(11):1755-1763. <https://doi.org/10.1016/j.soard.2018.07.032>
27. *Pasco, J. A., Nicholson, G. C., Brennan, S. L., & Kotowicz, M. A.*: Prevalence of obesity and the relationship between the body mass index and body fat: cross-sectional, population-based data. *PloS one* 2012;7(1):e29580. <https://doi.org/10.1371/journal.pone.0029580>
28. *Garvey, W. T.*: The diagnosis and evaluation of patients with obesity. *Current Opinion in Endocrine and Metabolic Research* 2019;4:50-57. <https://doi.org/10.1016/j.coemr.2018.10.001>
29. *Zeng, Q., Dong, S. Y., Sun, X. N., Xie, J., & Cui, Y.*: Percent body fat is a better predictor of cardiovascular risk factors than body mass index. *Brazilian J Med. Biol Res. = Revista brasileira de pesquisas medicas e biologicas* 2012;45(7):591-600. <https://doi.org/10.1590/s0100-879x2012007500059>
30. *Park, S. K., Ryoo, J. H., Oh, C. M., Choi, J. M., Chung, P. W., & Jung, J. Y.*: Body fat percentage, obesity, and their relation to the incidental risk of hypertension. *J Clinic Hypertens (Greenwich, Conn.)* 2019;21(10):1496-1504. <https://doi.org/10.1111/jch.13667>
31. *Gierach, M., Gierach, J., Ewertowska, M., Arndt, A., & Junik, R.*: Correlation between Body Mass Index and Waist Circumference in Patients with Metabolic Syndrome. *ISRN endocrinology* 2014:514589. <https://doi.org/10.1155/2014/514589>
32. *Sato, Y., Fujimoto, S., Konta, T., Iseki, K., Moriyama, T., Yamagata, K., Tsuruya, K., Narita, I., Kondo, M., Kasahara, M., Shibagaki, Y., Asahi, K., & Watanabe, T.*: Body shape index: Sex-specific differences in predictive power for all-cause mortality in the Japanese population. *PloS one* 2017;12(5):e0177779. <https://doi.org/10.1371/journal.pone.0177779>
33. *Aye, M., & Sazali, M.*: Waist circumference and BMI cut-off points to predict risk factors for metabolic syndrome among outpatients in a district hospital. *Singapore medical journal* 2012;53(8):545-550.
34. *Bouguerra, R., Alberti, H., Smida, H., Salem, L. B., Rayana, C. B., El Atti, J., Achour, A., Gaigi, S., Slama, C. B., Zouari, B., & Alberti, K. G.*: Waist circumference cut-off points for identification of abdominal obesity among the tunisian adult population. *Diabetes, Obes*

- Metab. 2007;9(6):859-868. <https://doi.org/10.1111/j.1463-1326.2006.00667.x>
35. Jacobs, E. J., Newton, C. C., Wang, Y., Patel, A. V., McCullough, M. L., Campbell, P. T., Thun, M. J., & Gapstur, S. M.: Waist circumference and all-cause mortality in a large US cohort. *Arch Intern Med.* 2010;170(15):1293-1301. <https://doi.org/10.1001/archinternmed.2010.201>
36. Cerhan, J. R., Moore, S. C., Jacobs, E. J., Kitahara, C. M., Rosenberg, P. S., Adami, H. O., Ebbert, J. O., English, D. R., Gapstur, S. M., Giles, G. G., Horn-Ross, P. L., Park, Y., Patel, A. V., Robien, K., Weiderpass, E., Willett, W. C., Wolk, A., Zeleniuch-Jacquotte, A., Hartge, P., Bernstein, L., ... Berrington de Gonzalez, A.: A pooled analysis of waist circumference and mortality in 650,000 adults. *Mayo Clinic Proceedings* 2014;89(3):335-345. <https://doi.org/10.1016/j.mayocp.2013.11.011>
37. Yu, J. Y., Choi, W. J., Lee, H. S., & Lee, J. W.: Relationship between inflammatory markers and visceral obesity in obese and overweight Korean adults: An observational Study. *Medicine* 2019;98(9):e14740. <https://doi.org/10.1097/MD.00000000000014740>
38. Zajac-Gawlak, I., Klapcińska, B., Kroemeke, A., Pośpiech, D., Pelclová, J., & Přidalová, M.: Associations of visceral fat area and physical activity levels with the risk of metabolic syndrome in postmenopausal women. *Biogerontology* 2017;18(3):357-366. <https://doi.org/10.1007/s10522-017-9693-9>
39. Katsuki, A., Sumida, Y., Urakawa, H., Gabazza, E. C., Murashima, S., Maruyama, N., Morioka, K., Nakatani, K., Yano, Y., & Adachi, Y.: Increased visceral fat and serum levels of triglyceride are associated with insulin resistance in Japanese metabolically obese, normal weight subjects with normal glucose tolerance. *Diabetes Care* 2003;26(8):2341-2344. <https://doi.org/10.2337/diacare.26.8.2341>
40. McNeely, M. J., Shofer, J. B., Leonetti, D. L., Fujimoto, W. Y., & Boyko, E. J.: Associations among visceral fat, all-cause mortality, and obesity-related mortality in Japanese Americans. *Diabetes care* 2012;35(2):296-298. <https://doi.org/10.2337/dc11-1193>
41. Singh, R., Prakash, M., Dubey, R., Roy, K., Kotwal, A., & Mahen, A.: Body composition parameters as correlates of coronary artery disease. *Indian J Med. Res.* 2013;138(6):1016-1019.
42. Gažarová, M., Galšneiderová, M., & Mečiarová, L.: Diagnostika obezity na základe pomeru obvodu pása a obvodu bokov a viscerálnej oblasti a ich vzťah k ďalším antropometrickým parametrom [Diagnosis of obesity based on the ratio of waist circumference and hip circumference and visceral area and their relation to other anthropometric parameters]. *Výživa - človek - zdravie* 2019;70-81. <https://doi.org/10.15414/2019.9788055220734> In Slovak

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VALIDATION OF CONCEPTUAL AND METHODOLOGICAL FRAMEWORK FOR THE STUDY OF DIETARY PRACTICES AND NUTRITIONAL STATUS OF AN ADULT POPULATION

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ABSTRACT

Background. The use of validated and reliable methods and instruments is necessary to study dietary practices and nutritional status due to their direct impacts on population health.

Objective. The aim is the validity and reliability of the conceptual and methodological framework of research on factors associated with dietary practices and nutritional status (FADPNS), carried out on adult population of the Rabat-Salé-Kenitra region in Morocco.

Material and methods. First, we developed a conceptual and methodological framework for research on FADPNS, which aimed to study dietary practices, nutritional status, and the factors associated with them in an adult Moroccan population. Then, we studied the validity and reliability of this framework in three phases. Phase 1 focused on the validation of the content of the conceptual and methodological framework, Phase 2 focused on the study by an expert committee of the internal consistency validity (ICV) of the questionnaires used in this research, and Phase 3 consisted of the study of the reliability of the items questionnaires by the test of Cronbach Alpha.

Results. Thus, the validated content of the conceptual framework of research on FADPNS includes socio-demographic, socio-economic, and socio-cultural characteristics; health status; physical activity, places of food purchase; food preparation, taking of meals, family commensality; social representations of good dietary practices; food consumption; and nutritional status. The questionnaires used in this research received an ICV score of 85%. The reliability test of the questionnaires showed a Cronbach Alpha value ≥ 0.5 , which turned out to vary from "moderate" to "excellent".

Conclusion. This work enabled the validation of the conceptual framework and the methodology of the study of the factors associated with dietary practices and nutritional status in the RSK region.

Key words: *validity, reliability, conceptual and methodological framework, dietary practices, nutritional status, Morocco*

INTRODUCTION

Eating behavior refers to the physiological, psychological, and social aspects of food intake and also to the social representations of dietary practices [1]. In general, these practices encompass food purchases, processing, preparation, and consumption that affect an individual's health while being dependent on social, spatial, and cultural diversity [2]. The different dietary practices, their repercussions on nutritional status, and their determinants are presented below. First of all, food purchases from traditional or modern markets contribute to determining the type of food consumed and thus convey cultural values [3]. For the cooking methods, although they have the advantage of making food healthier by destroying all or part of the

thermosensitive flora and eliminating many toxins, they could have an adverse effect on health if they are not well chosen [4]. In addition, the various cooking methods take different preparation times, which, the longer they are, the better the nutritional quality of the meal, since a long meal preparation time is generally associated with the use of primary foods with low reliance on processed foods that are predominantly high in calories, fat, and sodium [5]. Also, it is recommended to have regular meals, with a frequency of three main meals and two to three healthy snacks per day [6]. Nevertheless, the intake of snacks must be in line with the nutritional needs and specificities of each individual [7]. In addition, spending more time on meals has been associated with lower energy intake [8]. Regarding commensality and, more precisely,

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eating meals with the family, it has been associated with healthier eating habits [1]. It is evident that the pleasure of eating is important, but that of sharing food with loved ones or with family is also important [9]. Furthermore, eating outside the home, which is emerging globally, is considered a factor associated with the increase of obesity [10]. Similarly, the frequency of eating out-of-home meals and the quality of the food preparations served in various restaurants influence the nutritional status [11]. Moreover, there is a close relationship between consumers and their environment, both physical and social. In particular, the place where meals are taken is one of the physical factors involved in this relationship [12]. Besides, since the nutritional intakes defined by the type of food consumption represent a pillar of dietary practices, it is necessary to ensure adequate intakes of energy, nutrients, micronutrients, dietary fiber, and water [13]. In addition, several models of dietary behaviour have demonstrated an association of eating practices and behaviours with the representations made of them [14], with personal factors (gender, age, etc.), socio-cultural factors (family, social groups, norms and values), economic and political factors (income, budget coefficient, regulation), incentives (advertising, society), food product availability and the context of consumption [15].

Taking into account the literature cited above and in the absence of an established theory on our research topic, we have developed a conceptual frame of reference, which is a logical structure composed of variables brought together because of their relationship to the subject under study [16] (Figure 1). Furthermore, since dietary practices are essential for determining health status, they should be studied using reliable instruments. Therefore, the objective here is to study the validity and reliability of the conceptual and methodological framework developed for the research conducted in the adult population of the region of Rabat-Salé-Kenitra (RSK) in Morocco, on the factors associated with dietary practices and nutritional status (FADPNS). This work aims to validate the terms of reference and the methodology of the FADPNS research for the publication of its results.

MATERIALS AND METHODS

Sampling method

The FADPNS research, which is being validated in this article, began in 2018 and was completed in 2022. It affected 507 households¹ in urban and rural areas of the RSK region in Morocco, including the prefectures

of Rabat, Salé, Skhirate-Temara, and the provinces of Kenitra, Khemisset, Sidi Kassem and Sidi Slimane.

Two adults were recruited from each household. The former has a primary role and the latter has a secondary role in food purchases and meal preparation. Thus, two groups were formed. Group 1 is called «household representatives» and group 2 is called «study population». Data of household food purchases and meal preparation were collected from «household representatives» while data on meal intake, health status, physical activity, dietary intake, and nutritional status were collected from the «study population».

The recruitment of two members per household on the condition that at least one member has information on food purchases and meal preparation was essential for this study. On the one hand, it ensured answers to questions about this component of food practices since not all household members necessarily have this information, and on the other hand, it has made it possible to have a population where women and men are represented, thus promoting the study of food practices and nutritional status in both sexes. Indeed, in this type of study, there is a risk that the researcher will end up with an entirely female population since the preparation of meals is generally done by women [17, 18, 19].

Inclusion and exclusion criteria

The inclusion criteria common to household representatives and the population studied is that they must be over the age of 18 and be Arabic-speaking (regardless of ethnicity). Indeed, the methodology was developed and tested in dialectal Arabic. As a criterion of inclusion specific to household representatives, we have retained the fact that they have all the information on food purchases and the preparation of meals adopted in their households. As a specific exclusion criterion for the study population, we have retained pregnancy status as it affects anthropometric measurements.

Data collection

To ensure triangulation of data collection methods, we developed three questionnaires, a food history guide, and a food frequency. In addition, we used the Marshal questionnaire for physical activity assessment as well as clinically valid equipment for blood pressure, heart rate, anthropometry, and body composition measurements.

The questionnaire 1 was developed to collect general data from household representatives common to household members, in particular socio-demographic, socio-economic, and socio-cultural characteristics, food purchases, and meal preparation (cooking methods, frequency, and duration of meal preparation).

¹ Household: is a group of individuals living under the same roof and having common daily expenses, but not necessarily related (HCP of Morocco ; Glossary 2015) ; <https://www.hcp.ma/glossary/>.

The questionnaire 2 was developed to collect individual data from the study population, specifically socio-demographic characteristics, health status, physical activity, intakes and nutritional status, and meal intake (hours, frequency, locations, meal times, and family relationships).

The questionnaire 3 was developed to collect data on social representations of good dietary practices among household representatives and among the population studied. Indeed, in addition to the interview, it is possible to carry out qualitative surveys with questionnaires and on large samples in order to gather not only the opinions of the respondents but also the organization of their representations [20].

The Food Frequency Guide was developed to collect data on the frequency of consumption of natural and processed foods within households. A closed list of foods that are part of the Moroccan eating habits has been designed, taking into account the development methods of this type of instrument [21].

The Food History Guide was developed to study the food consumption of the study population because it is the most appropriate type of survey to assess subjects' typical eating habits over a given period of time [21]. In addition, an iconographic manual was used to estimate the quantities of food and food preparations consumed [22].

The Marshal questionnaire, which is used to identify subjects who are insufficiently active in primary health care, was selected for the physical activity assessment of the study population [23,24]. We have made sure to adapt the types of sports that appear in it to the Moroccan context.

The OMRON M3 type arm blood pressure monitor has been selected for taking blood pressure and measuring the heart rate of the group of household members. The measurement of blood pressure by this blood pressure monitor is clinically validated according to protocols having international recognition for its use in the general normotensive or hypertensive population [25].

The OMRON BF 214 brand 4-sensor impedance meter was selected for measuring the Body Mass Index (BMI) and body composition in fat mass and muscle mass of the group of household members. It is a medical device using the bioelectric impedance method. This material is validated clinically in accordance with current protocols [26].

Pre-test

The pre-test of the methodology was carried out using a preliminary survey of 20 households in the RSK region. It allowed some questions to be reformulated and readjusted. It also allowed estimating the duration of the questionnaire administration, which was around 40 minutes.

Statistical analysis

The statistical analysis of the results of FADPNS' research was performed by SPSS for Windows (Statistical Package for the Social Sciences) version 21 and Microsoft Office Excel 2007. Microsoft Bilnut version 2.01 was used to calculate the nutritional value of dietary intakes. To determine factors associated with dietary practices and nutritional status, various static tests were used with a threshold of significance: $p < 0.05$.

For the study of internal consistency validity (ICV) of the questionnaires used in FADPNS' research, we have submitted the questionnaires developed above to a committee of experts [27, 28, 29, 30]. In addition, for the study of reliability of those questionnaires we used the Cronbach Alpha test with the following reliability thresholds: 1) Excellent reliability, if $\alpha \geq 0.90$; 2) High reliability, if $0.70 \geq \alpha < 0.90$; 3) Moderate reliability, if $0.50 \geq \alpha < 0.70$; and 4) Low reliability if $\alpha < 0,50$ [27-30].

Ethical considerations

This study has been authorized by the Wilaya and the Regional Health Directorate of the Rabat-Salé-Kenitra region (RSK). The fundamental ethical principles governing the conduct of the research were respected, including the provision of information to study participants, volunteering, anonymity, confidentiality, and the right to interrupt their participation in the study at any time. In addition, free and informed consent was obtained from the participants before the administration of the questionnaires and the taking of the measurements.

RESULTS

In order to study validity and reliability of the conceptual and methodological framework of FADPNS research developed above, we carried out three phases:

Phase 1. Validation of the content of the conceptual and methodological framework

In this phase, we have submitted the conceptual and methodological framework for evaluation to a committee of experts in nutrition, dietetics, public health, and statistics. The evaluation of the conceptual framework (Figure 1) consisted of studying the relevance and completeness of the concepts and the relationships between them, while the evaluation of the methodological framework (presented above) consisted of studying the relevance of the sampling, data collection methods and materials, items and variables under study, statistical analysis, and ethical considerations.

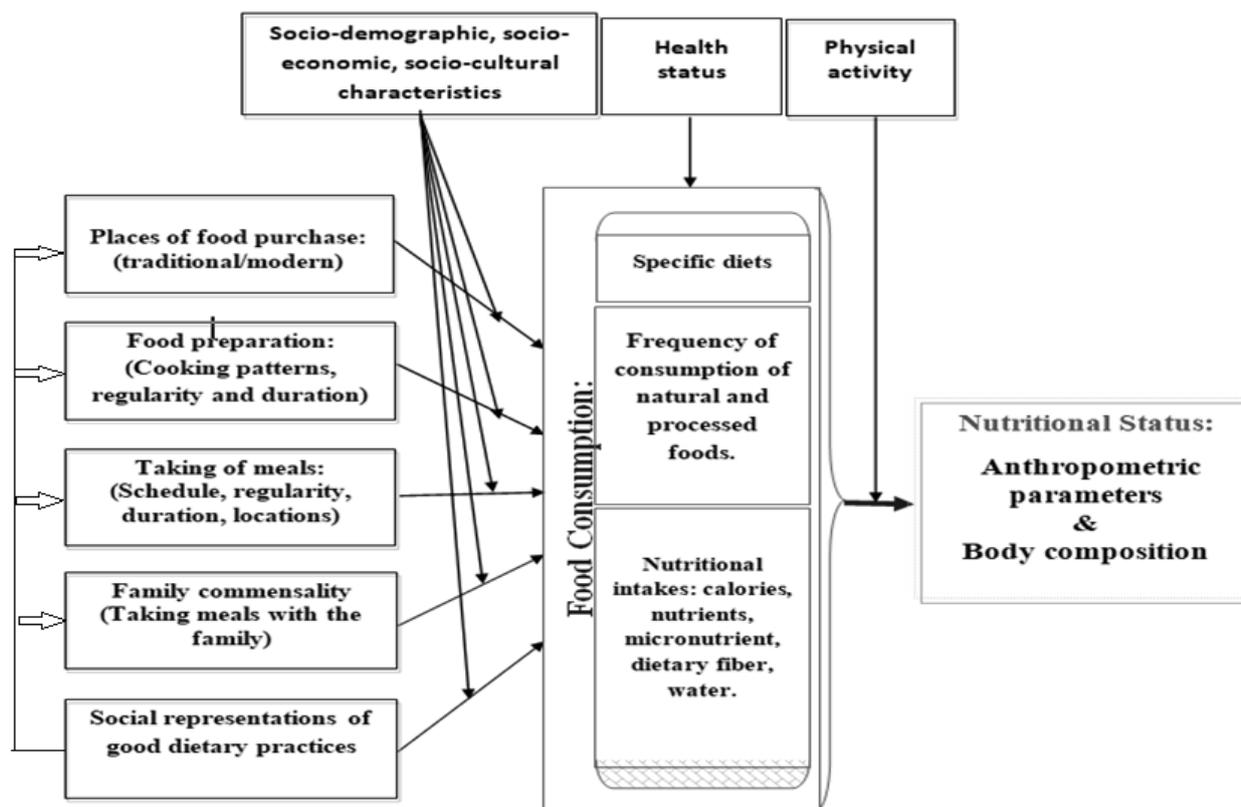


Figure 1. Conceptual Reference framework

Phase 2. Internal Consistency Validity of questionnaires

At the outset, the Committee of Experts allocated to the questionnaires an initial Internal Consistency Validity (ICV) score of 75%. Then, and after incorporating the changes and readjustments proposed by the Expert Committee, this ICV was recalculated and an 85% ICV index was reassigned to the final versions of these questionnaires.

The items retained following the ICV validation of the internal consistency of the questionnaires are presented below:

Items under study in the group of household representatives are sociodemographic, sociocultural, and socioeconomic characteristics studied (age, gender, education level, occupation, marital status, place of residence, geographical origin, ethnic origin, family type², household size³, monthly income, standard of living), overall expenditure and household food expenditure; food shopping places; frequency of natural and processed food consumption; and meal preparation.

The items specific to the study population are: socio-demographic characteristics (age, sex, level of education, occupation, marital status) [15]; nutritional status measured by body mass index [31], waist circumference and hip circumference ratio [32, 33]; body composition in fat and muscle mass [26]; respondents' attitudes towards their perception of their weight status; health status (heart rate [34], blood pressure [35]; reported diseases; specific diets applied; physical activity; meal intake; nutritional intakes [13, 36, 37, 38]); and finally, diversity and dietary variety.

Social representations of good dietary practices have been studied both among household representatives and among the population studied. The items selected are cooking methods; traditional preparations; modern preparations; foods recommended by religion, organic foods; home meals; the use of spices and aromatic plants; palatability (delicious preparations); and the regularity of taking meals. Thus, the participants were asked to choose from the nine proposed items, the three that they felt most characterized (MC) good dietary practices, and then choose from the remaining six items, the three that least characterized (LC) good dietary practices. This results in three non-selected items (NS) for each respondent. A code was assigned to each characterization: code (1) for the least characteristic items, code (2) for the non-selected items, and code (3) for the most characteristic items [20, 39].

² Family type: A family can be nuclear or extended. A nuclear family is composed of a single nucleus and can be a couple or a single parent, with or without children, or can be a sibling. An extended family includes several nuclei and may also include uncles and aunts, grandparents, cousins, nephews, and grandsons. Glossary 2015; HCP (Morocco); <https://www.hcp.ma/glossary/>.

³ Household size: the number of people in a household (HCP of Morocco; Glossary 2015; <https://www.hcp.ma/glossary/>).

Phase 3. Reliability study of the questionnaires

We present below the study of the reliability (by *Cronbach Alpha* test) of the items relating to the sources of food information, the use of places to buy food, the frequency of consumption of natural and processed foods, and the preparation and teaking meals.

The Table 1 shows that the Cronbach's Alpha coefficient is 0.51 for «food information sources», it is 0.54 for «places attendance of food shopping», and it is 0.7 for «preparation of meals».

The Table 2 shows that the *Cronbach's Alpha* coefficient is 0.6 for the items «frequency of natural food consumption» and « frequency of processed food consumption ».

Table 1. Reliabilty of food information sources, places attendance of food shopping, and meals preparation

Items & variables		Categories	Alpha of Cronbach
Food information sources	Parents and grandparents, friends and family, health professionals, the Internet, scientific journals and the media.	1) Yes 2) No	0.51*
Places of food shopping	Food shopping places: markets and souks, large and medium-sized stores, grocery stores (retail locations), wholesalers and outlets for organic and farm food.	1) < 1/w 2) ≥ 1/w	0.54*
	Factors influencing the choice of food shopping places: health, cost, proximity, ease of payment, relationship.	1) Yes 2) No	
Meals preparation	Culinary modes: stewing, steaming, baking, frying and grilling.	1) < 4 /w 2) ≥ 4 /w	0.7**
	Criteria of choice of culinary modes: health, short duration, palatability, traditional appearance.	1) Yes 2) No	
	Frequency of preparation of meals and snacks: breakfast, lunch, dinner, morning, afternoon and evening snacks.	1) < 5 /w 2) ≥ 5 /w	
	Factors influencing the frequency of preparation of meals and snacks: eating habits and culture, health status, availability and expert advice.	1) Yes 2) No	
	Daily meal preparation time.	1) < 3 h/d 2) ≥ 3 h/d	
	Duration of breakfast preparation	1) <30 mn 2) ≥30 mn	
	Duration of lunch preparation	1) < 2 h/d 2) ≥ 2 h/d	
	Duration of afternoon snak preparation	1) <30 mn 2) ≥30 mn	
	Duration of dinner preparation	1) < 1 h 2) ≥ 1 h	
Factors influencing meal preparation time: lack of time, type of preparation, number of guests	1) Yes 2) No		

*= moderate reliability; **= high reliability; w= week; d= day; h= hour; mn= minute.

Table 2. Reliability of consumption frequency of natural and processed foods

Items & variables		Categories	Alpha of Cronbach
Frequency of natural foods consumption	Whole wheat, barley, fresh vegetables, pulses, fresh fruits, dried fruits rich in carbohydrates such as dates and dried figs, oilseeds (almonds, nuts, peanuts, etc.), fish, olive oil, argan oil, red meat (beef, veal, sheep), farm chicken, farm egg, bulk milk, natural cheese (Jben), whey, curd milk, farm butter, honey and tea.	1) < 3/w 2) ≥ 3/w	0.6*
frequency of processed foods consumption	Refined flours, pasta, pastries, commercial sweet cakes (including pastries), cornflakes, chips, packaged milk, industrial cheese, industrial yogurt, industrial chicken, industrial egg, industrial animal butter, mayonnaise, chocolate, and lemonade and sodas.		

*= moderate reliability; w = week.

The Table 3 shows that the *Cronbach's Alpha* coefficient is 0.5 for the item «taking meals with the family», it is 0.6 for the items «health status and physical activity» and «taking meals away from home», and it is 0.7 for the item «frequency and duration of taking meals».

The Table 4 shows that the *Cronbach's Alpha* coefficient is 0.5 for the items «characterization of foods recommended by the religion» and «characterization of the regularity of meals intake», it is 0.53 for the item «characterization of traditional preparations», it is 0.55 for the item «characterization of organic food», it is 0.6 for the items «characterization of eating at home» and «characterization of palatability», it is 0.7 for the item «characterization of the use of spices and aromatic

plants», and it is 0.9 for the items «characterization of cooking methods» and «characterization of modern preparations».

DISCUSSION

The purpose of this article was to study the validity and reliability of the conceptual and methodological framework of the research on factors associated with dietary practices and nutritional status (FADPNS) that we conducted in the adult population of the Rabat region-Salé-Kenitra in Morocco. Certainly, the food consumption and nutritional status of the Moroccan population have been studied by various academic, scientific, and ministerial bodies. However, no previous

Table 3. Reliability of health status, physical activity, and meals intake

Items & variables		Categories	Alpha of Cronbach
Health status and physical activity	Pathologies: hypertension, type 2 diabetes, dyslipidemia	1) Yes 2) No	0.6*
	Specific diets: Hypocaloric, Hypoglucidic, Hypolipidic, Hyposodium	1) Yes 2) No	
	Physical activity	1) Sufficiently active 2) Insufficiently active	
Schedule, frequency, and duration of taking meals	Meal Intake Schedule	1) Régular 2) variable	0.7**
	Frequency of meal intake	1) < 3 meals/d 2) 3 meals/d	
	Factors influencing frequency of meal intake: suitability, expert advice, family habits, lifestyle	1) Yes 2) No	
	Length of time meals and snacks taken	1) < 90 mn 2) ≥ 90 mn	
	Factors influencing Length of time meals and snacks taken: commensality, availability, type of preparation, location of meals	1) Yes 2) No	
Taking meals with the family	Frequency of family meals: breakfast, lunch and dinner	1) ≤ 1 meal/d 2) ≥ 2 meals/d	0.5*
	Factors influencing: culture and traditions, friendliness, economic factor	1) Yes 2) No	
Taking meals away from home	Frequency of out-of-home meals: breakfast, lunch and dinner	1) < 1 /w 2) ≥ 1 /w	0.6*
	Frequency of out-of-home snacks: morning snack, afternoon snack, evening snack	1) < 1 /w 2) ≥ 1 /w	
	Factors contributing to out of home eating: change, obligation and working conditions, new lifestyles and modernization	1) Yes 2) No	
	Places where meals are taken: dairies, tea rooms/cafes/pastries, traditional Moroccan restaurants, fast food restaurants, restaurants offering fish specialties, restaurants with Western/Asian specialties, workplaces	1) < 1 /w 2) ≥ 1 /w	
	Criteria for choosing places to eat meals outside the home: proximity, hygiene, prices, palatability.	1) Yes 2) No	

*= moderate reliability; **= high reliability; w = week; d = day; h = hour; mn = minute.

Table 4. Reliability of social representations of dietary practices

Items & variables	Categories	Alpha of Cronbach
Characterization of cooking methods	1) LC ; 2) NS ; 3) MC	0.9***
Characterisation of traditional preparations	1) LC ; 2) NS ; 3) MC	0.53*
Characterization of modern preparations	1) LC ; 2) NS ; 3) MC	0.9***
Characterisation of foods provided by religion	1) LC ; 2) NS ; 3) MC	0.5*
Characterisation of organic food	1) LC ; 2) NS ; 3) MC	0.55*
Characterisation of home-eating	1) LC ; 2) NS ; 3) MC	0.6*
Characterization of the use of spices and aromatic plants	1) LC ; 2) NS ; 3) MC	0.7**
Characterisation of palatability	1) LC ; 2) NS ; 3) MC	0.6*
Characterisation of the regularity of taking meals	1) LC ; 2) NS ; 3) MC	0.5*

*= moderate reliability; **= high reliability; ***= excellent reliability; LC= least characteristic items; NS = items not selected; MC = most characteristic items

studies have simultaneously examined overall dietary practices, the nutritional status assessed by various anthropometric indicators, and the factors associated with them. The results of this research, which will be published later, have confirmed the concept of «hidden hunger» as an effect of the nutritional transition in Morocco, marked by a double burden of overload and deficiency diseases; and, on the other hand, they have revealed determinants of food practices specific to the Moroccan context on which it is necessary to act to improve the nutritional status of the population.

In order to further the objective of the present work, we have carried out three phases: the study of the validity of the conceptual and methodological framework, the study of the ICV, and the study of the reliability of the questionnaires. The study of the validity of the conceptual and methodological framework of this research was carried out by an expert committee after an evaluation of its content. Indeed, in the absence of an established theory of overall dietary practices, their influences and their consequences, we have developed a conceptual framework that encompasses the different concepts related to the subject under study, food purchases, meal preparation, meals and snacks, family commensality, social representations of good food practices, socio-demographic, socio-economic, and socio-cultural characteristics, health status, physical activity, intakes, and nutritional status [15]. In addition, we developed the methodological framework including the sampling method, the data collection process and instruments, the statistical analysis, and ethical considerations [16]. The validity study of the questionnaires used in the research of FADPNS showed a final ICV equal to 85%. This proves that these questionnaires have received a good VCI and therefore are valid for measuring what they were built for [27, 29, 30]. In addition, cronbach's alpha reliability test [27, 28, 29, 30] showed high reliability ($0.70 \leq \alpha < 0.90$) for the item «meal preparation», and moderate reliability ($0.50 \leq \alpha < 0.70$) for items, «food

information sources», and «food purchase locations» whereas for «food consumption frequency», this test showed moderate reliability ($0.50 \leq \alpha < 0.70$). Also, this test revealed a high reliability ($0.70 \leq \alpha < 0.90$) for the item «meals intake» and moderate reliability ($0.50 \leq \alpha < 0.70$) for items, «health status and physical activity», «eating with the family», and «eating out-of-home». For the social representations of food practices, this test revealed an excellent reliability ($\alpha \geq 0.90$) for the characterization of «cooking methods» and for «modern preparations», a high reliability ($0.70 \leq \alpha < 0.90$) for the characterization of «use of spices and aromatic plants» and a moderate reliability ($0.50 \leq \alpha < 0.70$) for the characterization of «traditional preparations», «foods recommended by religion», «organic food», «eating at home», «palatability», and «regularity of taking meals».

However, variables measured by valid equipment for which evaluation standards are available in the literature were not evaluated by the internal consistency study. These factors include heart rate, blood pressure, status, and nutritional intake [13, 26, 31-38]. Similarly, socio-demographic, socioeconomic, and socio-cultural characteristics were inspired by the literature [15] and were not the subject of an internal coherence study.

CONCLUSION

This work enabled the validation of the conceptual framework and the methodology of the study of the factors associated with dietary practices and nutritional status in the RSK region.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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REFERENCES

- Dupuy, A.: Regard(s) « sur » et « par » l'alimentation pour renverser et comprendre comment sont renversés les rapports de générations : l'exemple de la socialisation alimentaire inversée, EFG, no 20, p. 79-108, 2014, doi : 10.7202/1025331ar.
- Kessous A., Chalamon I.: Représentations mentales de la consommation et des pratiques alimentaires : Approche par le carré sémiotique "bon/mauvais", La Revue des Sciences de Gestion, vol. N° 261-262, no 3, p. 51-58, sept. 2013.
- Amine, A., et Lazzaoui, N.: Rôle de la distribution moderne dans l'évolution des pratiques de consommation dans les pays émergents: Cas de la distribution alimentaire au Maroc, Revue Marocaine de Recherche en Management et Marketing, 2009, no 1, Art. no 1, doi: 10.48376/IMIST.PRSM/remarem-v0i1.3381.
- Buratti, S., Cappa, C., Benedetti, S., Giovanelli G.: Influence of Cooking Conditions on Nutritional Properties and Sensory Characteristics Interpreted by E-Senses: Case-Study on Selected Vegetables. Foods, 2022 ;9(5):607, doi: 10.3390/foods9050607.
- Appelhans, M., et al.: Meal preparation and cleanup time and cardiometabolic risk over 14 years in the Study of Women's Health Across the Nation (SWAN), Prev Med, 2015;71 :1-6; doi: 10.1016/j.ypmed.2014.11.025.
- Vanhauwaert, E.: De actieve voedingsdriehoek, 1st edition. Leuven; Den Haag: Acco Uitgeverij België, 2012.
- Naessens, E.: Maaltijden. In de kijker. Nutrinenews 2015;1:18-23.
- Robinson, E., et al.: A systematic review and meta-analysis examining the effect of eating rate on energy intake and hunger. Am J Clin Nutr, 2014;100 (1) :123-151, doi: 10.3945/ajcn.113.081745.
- Alba, J.W., Williams, E.F.: Pleasure principles: A review of research on hedonic consumption, J. Consum Psychol, 2013;23(1):2-18; doi: 10.1016/j.jcps.2012.07.003.
- Allali, F.: Evolution des pratiques alimentaires au Maroc. International Journal of Medicine and Surgery 2017, p. 71.
- Barakat, I., ElFane, H., Daïf, H., Elayachi, M., Belahsen, R.: Eating out-of-home and associated nutritional status of an adult population from Rabat-Salé-Kenitra region of Morocco. Int J Food Scie Nutr 2020;5(4):53-58.
- Boussoco, J., Dany, L., Giboreau, A., Urdapilleta I.: Faire la cuisine: approche socio-représentationnelle et distance à l'objet, Les Cahiers Internationaux de Psychologie Sociale, 2016 ;111(3):367-395.
- WHO. Diet, nutrition and the prevention of chronic diseases : report of a joint WHO/FAO expert consultation. World Health Organization, Geneva 2003. <https://apps.who.int/iris/handle/10665/42665>
- Rolls, E.T.: Taste, olfactory, and food reward value processing in the brain. Prog Neurobiol, 2015;127-128, p. 64-90, doi: 10.1016/j.pneurobio.2015.03.002.
- Rastoin, J. L., Gherzi, G.: Le système alimentaire mondial. Éditions Quæ, 2010. doi: 10.3917/quae.rasto.2010.01.
- Fortin, M.F., Gagnon, J., Fondements et étapes du processus de recherche: méthodes quantitatives et qualitatives. Chenelière éducation, 2016.
- Barakat, I., Kalili, A., Moustakim, R., Elouafi, R., El Mahri, N., Belahsen, R., et al.: Food Consumption Trends and Associated Factors in an Agricultural Community in Morocco, OAJBS, 2020;1(6), doi: 10.38125/OAJBS.000160.
- Elfane, H. et al.: Association of obesity with the lower limbs osteoarthritis in a community of women from El Jadida province in Morocco, NAJFNR, 2019;3(1):156-163.
- El-Jamal, S., et al.: Association between food insecurity and obesity in an agricultural community of women from El Jadida, Morocco, AIMS MEDS, 2021;8(3), art. no medsci-08-03-016, doi: 10.3934/medsci.2021016.
- Vergès, P.: L'analyse des représentations sociales par questionnaires. Revue Française de Sociologie 2021;42(3)3:537-561, doi: 10.2307/3323032.
- Rutishauser, H.: Dietary intake measurements, Publ Health Nutr 2005;8(7a):1100-1107, doi: 10.1079/PHN2005798.
- Dufourny, G., Elmoumni, K., Maimouni, E.: Aliments et préparations typiques de la population Marocaine, Outil pour estimer la consommation alimentaire, Centre d'Information et de Recherche sur les Intolérances et L'Hygiène Alimentaires (CIRIHA). 2008.
- Inserm. Inégalités sociales de santé en lien avec l'alimentation et l'activité physique, Inserm, La science pour la santé, 2014. <https://www.inserm.fr/expertise-collective/inegalites-sociales-sante-en-lien-avec-alimentation-et-activite-physique/>
- Marshall, A. L., Smith, B. J., Bauman, A. E., Kaur, S.: Reliability and validity of a brief physical activity assessment for use by family doctors. British J Sports Medicine 2005;39(5):294-297, doi: 10.1136/bjism.2004.013771.
- ANSM. Liste des autotensiomètres enregistrés et publiés depuis le 1er janvier 2006 - Modèles bras (Huméraux) - brassard de taille standard, Agence Nationale de Sécurité du Médicament et des Produits de santé, 2012 p. 5.
- OMRON. Omron BF214 Instruction manual, manualzz.com, 2013. <https://manualzz.com/download/2545147>
- Taherdoost, H.: Validity and Reliability of the Research Instrument. How to Test the Validation of a Questionnaire/Survey in a Research, IJARM, 2016, doi : 10.2139/ssrn.3205040.
- Kennedy, L-G., Kichler, E.J., Seabrook, J-A., Matthews, J.I., Dworatzek, P.D.N.: Validity and Reliability of a Food Skills Questionnaire, J Nutr Educ Behav 2019;51(7):857-864, juill. 2019, doi: 10.1016/j.jneb.2019.02.003.

29. Barakat, I., et al.: Validation of the Questionnaire Used in the Transnational Study on Lifestyles Adopted in the Era of the COVID-19 Pandemic *www.ijssrm.humanjournals.com*, janv. 2020.
30. Bédard, S.K., et Larivière. C.: Processus de validation du questionnaire IPC65 : un outil de mesure de l'interdisciplinarité en pratique clinique, *Sante Publique*, 2013;25(6):763-773.
31. WHO. International Classification of adult underweight, overweight and obesity according to BMI, 2014. http://apps.who.int/bmi/index.jsp?introPage=intro_3.html
32. WHO. Obésité : prévention et prise en charge de l'épidémie mondiale : rapport d' une consultation de l'OMS, Organisation mondiale de la Santé, 2003. <https://apps.who.int/iris/handle/10665/42734>
33. Oppert, J.M.: Obésités : quelles mesures pour les « phénotypes » à risque cardiovasculaire ?, *Sang Thrombose Vaisseaux*, 2003;15(9):551-556.
34. Santé E.: Pouls et rythme cardiaque :les valeurs normales, Rédaction E-Santé, 2018. <https://www.e-sante.fr/pouls-et-rythme-cardiaque-les-valeurs-normales/actualite/615242>
35. WHO-EMRO. Journées mondiales de la Santé précédentes. Qu'est ce que l'hypertension artérielle, 2019. <http://www.emro.who.int/fr/pdf/world-health-days/journee-mondiale-de-la-sante-2013/public-health-problem-factsheet-2013.pdf?ua=1>
36. Journal Officiel de l'Union Européenne, Règlement (UE) n°1169/2011 du Parlement Européen et du Conseil, 25 octobre 2011. https://www.senat.fr/europe/textes_europeens/ue0120.pdf
37. Medicine Institute. Dietary Reference, Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. 2002. doi: 10.17226/10490.
38. IFN.Nutrition et Besoins en Eau. Institut Français pour la Nutrition, 2004;15, <https://alimentation-sante.org/wp-content/uploads/2011/07/dossier-scient-15.pdf>
39. Barakat, I., Elayachi, M., Belahsen, R.: Social representations of dietary practices and their determinants in a Moroccan community, *SHS Web Conf.* 2021;119,02003, doi: 10.1051/shsconf/202111902003.

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RISK FACTORS FOR LOW BIRTH WEIGHT IN EL JADIDA PROVINCE, MOROCCO. CASE-CONTROL STUDY

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ABSTRACT

Background. Low birth weight (LBW) is considered to be one of the most important indicators of a newborn's chances of survival, and a major risk of medium- and long-term morbidity.

Objective. To identify risk factors associated with low birth weight newborns among pregnant women during childbirth in Moroccan hospital environment with a view to proposing avenues of intervention for its prevention.

Material and methods. Data concerning the weight of newborns at birth, nutritional education, pregnancy monitoring and other risk factors, etc. were collected from 312 pregnant women who gave birth in the maternity ward of El-Jadida Provincial Hospital in Morocco.

Results. The study identified 156 cases of newborns with LBW and 156 controls of normal-weight newborns. After adjustment for the variables included in the analysis, the determined factors associated with LBW are nutritional education [OR: 6.22 (2.60-14.87), $P < 0.001$], illiterate women [OR: 8.74 (1.65-46.08), $P = 0.011$], insufficient pregnancy monitoring [OR: 5.69 (2.74-11.83), $P < 0.001$], pregnant women with a normal weight [OR: 3.84 (1.73-8.52), $P = 0.001$], lack of psychological support [OR: 3.23 (1.72-6.08), $P < 0.001$] and tiring domestic activity [OR: 2.13 (1.14-3.99), $P = 0.017$].

Conclusion. Promotion of nutrition for pregnant women, proper implementation of maternal health programs and improvement of their social condition are the modifiable factors that should help reduce LBW risk.

Key words: low birth weight, risk factors, pregnancy, newborn

INTRODUCTION

Low birth weight (LBW) is defined as a birth weight less than 2,500 grams, regardless of gestational age [1]. It is a major health problem responsible for neonatal mortality and morbidity such as diabetes, obesity and cardiovascular disease in adulthood [2]. In the medium term, babies with LBW are more likely to experience health and developmental problems, including impaired cognitive and physical development with learning difficulties, hearing and visual impairments [3]. Globally, low birth weight contributes 60 to 80% of all neonatal deaths. During 2017, nearly 20.5 million children were registered with low birth weight [4], 96.5% of whom were born in developing countries [4]. In 2015, Morocco recorded a proportion of births with an estimated low weight of 17.3%. A rate that appears very far from that of

Sweden (2.5%), higher than that of Algeria (7.3%) and Tunisia (7.5%) and closer to that of Senegal (18.5%) [4]. Millennium Development Goal 4 aims to reduce the death rate of children aged 0 to 5 by two thirds and, more specifically, to reduce underweight children in this age group [5]. However, the care of newborns with a growth deficit by the health system in developing countries is very expensive and, in general, remains insufficient or inadequate [6].

In 2018, Morocco recorded a neonatal mortality rate of 13.56 per 1,000 live births, of which low birth weight is one of the main causes. However, despite the efforts made for the prevention and the advancement of knowledge concerning the risk factors of LBW, inequities in access to obstetric and neonatal care persist between urban / rural areas, between regions and between socio-economic levels, raising questions about the quality of care for these newborns [7]. It

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should be noted that the two mechanisms most cited in the literature that determine low birth weight are prematurity and intrauterine growth retardation. Indeed, the causes and consequences of LBW are complex and intervene in the life cycle of individuals including their intrauterine nutritional environment, which remains the ultimate determinant of subsequent growth and state of health and from individual to individual adulthood [8].

In the present study, the objective was to determine the factors associated with low birth weight in a Moroccan hospital environment with a view to proposing avenues of intervention for its prevention.

MATERIAL AND METHOD

The study took place at the maternity ward of El-Jadida Provincial Hospital over a period from January 1 to December 31, 2018. This hospital represents a 2nd level public health structure with a high influx of the rural population.

Sample

This cross-sectional case-control study was conducted on mothers and their newborns of normal weight ($n = 156$) or low birth weight ($n = 156$) at the time of delivery. A low birth weight child (LBW) is defined as any newborn whose birth weight is less than 2500g regardless of the term of pregnancy. A normal weight child (NW) is defined as any newborn whose birth weight between 2,500 and 4,000 grams.

Inclusion and exclusion criteria

Inclusion and exclusion criteria: Included in this study are all children born alive and their mothers. Stillbirths and fetal deaths in utero are excluded from the study.

Information collected

The information was collected using an established questionnaire, making it possible to collect data on socio-demographic, gestational and nutritional factors.

Collection of anthropometric data at childbirth

In women: The anthropometric parameters of the parturient were measured according to the procedures recommended by the WHO. Pregnant women were weighed before delivery on electronic bathroom scales with an accuracy of 100 grams. The height was measured to the nearest millimeter using a wall chart.

The Body Mass Index (BMI) was calculated by dividing an individual's weight in kilograms by the square of their height in meters. An individual is said to be lean when BMI is strictly less than 18.5 kg / m², normal if BMI is in the range $\geq 18.5-25 <$, overweight

if BMI is in the range $\geq 25-30 <$ and obese if they have a BMI greater than or equal to 30 kg / m² [9].

In the newborn: At delivery, the weight was measured with an accuracy of 10 grams using a mechanical baby scale of the SECA® type.

Statistical analyzes

Statistical analyses are performed using SPSS version 23 software. Univariate and multivariate analysis was performed using chi-square test to separately study the independent variables associated with the dependent variable (LBW). The percentages of low birth weight were compared in the different modalities of the independent variables collected. Multivariate analysis was performed using binary logistic regression to identify the factors associated with low birth weight of newborns. The *Hosmer* and *Lemeshow* test was used to study the fit of the results to the data. The 5% significance level was used in all analyzes, both univariate and multivariate.

Ethical considerations

The investigation obtained the approval of the regional directorate of the Moroccan Ministry of Health in greater Casablanca. Participation in the survey was subject to the free and informed consent of the selected women. After receiving a detailed explanation of the survey process and conditions, the female respondents were informed that they were free to decline or withdraw from the survey at any time.

RESULTS

Table 1 illustrates the distribution of birth weight according to the characteristics of the mother and the newborn. According to the mothers characteristics, the table shows that the proportions of LBW are higher among mothers aged 18 to 34 years old (76.3%), illiterate parturient (71.2%), those with low socioeconomic level (73.3%), in first-time mothers (67.9%), parturient who have a pregnancy follow-up < 4 ANC: antenatal consultation (87.8%), those who did not receive nutritional advice during gestation (91.7%), those who were not psychologically supported during pregnancy (57.1%) and those with overweight (50.60%).

Table 2 reports the results of univariate and multivariate analysis by binary logistic regression. The factors significantly associated with the risk of low birth weight were in descending order: illiterate women [OR: 8.74 (1.65-46.08), $P=0.011$] and women with an average level of education [OR: 11.94 (1.89-75.50), $P=0.008$]; women with poor follow-up of prenatal consultation [OR: 5.69 (2.74-11.83), $P<0.001$]; women who are of normal weight during pregnancy [OR: 3.84 (1.73-8.52), $P=0.001$] and those who are

Table 1. LBW risk factors according to maternal and pregnancy characteristics

Maternal characteristics	Newborn LBW	Newborn NW	<i>P</i>
	N (%)	N (%)	
Mother's age			
<18 years	20 (12.8)	5 (3.2)	0.006
18-34 years	119 (76.3)	128 (82.1)	
> 35 years	17 (10.9)	23 (14.7)	
Study level			
Illiterate	111 (71.2)	79 (50.6)	0.001
Primary	19 (12.7)	42 (26.9)	
Middle School	23 (14.7)	26 (16.7)	
high school	3 (1.9)	9 (5.8)	
Socio-economic level			
Low	115 (73.3)	92 (59)	0.011
Medium	37 (23.7)	52 (33.3)	
High	4 (2.6)	12 (7.7)	
Parity			
Primiparous	106 (67.9)	77 (49.5)	0.001
Multiparous	50 (32.1)	79 (50.6)	
Monitoring of ANC			
<4 ANC	137 (87.8)	85 (54.5)	<0.001
≥4 ANC	19 (12.2)	71 (45.5)	
BMI classes			
<18.5 lean	0	1 (0.6)	<0.001
≥18.5; 25 <Normal weight	15 (9.6)	58 (37.2)	
≥25; 30 <overweight	79 (50.6)	89 (51.1)	
≥ 30 obese	62 (39.7)	8 (5.1)	
Nutrition education			
Yes	13 (8.3)	48 (30.7)	<0.001
No	143 (91.7)	108 (69.3)	
Newborn sex			
Female	94 (60.3)	106 (67.9)	0.097
Male	62 (39.7)	50 (32.1)	
Tiring domestic activity			
Yes	70 (44.9)	95 (60.9)	0.003
No	86 (55.1)	61 (39.1)	
Psychological support			
Yes	67 (42.9)	107 (68.6)	<0.001
No	89 (57.1)	49 (31.4)	
Passive smoking			
Yes	71 (45.5)	83 (53.2)	0.106
No	85 (54.4)	73 (46.7)	

LBW: Low birth weight; NW: normal weight; ANC: Antenatal consultation; BMI: body mass index

Table 2: Crude ORs of low birth weight as a function of maternal and newborn characteristics (univariate and multivariate analysis).

Maternal characteristics	Univariate analysis			Multivariate analysis		
	OR	CI (95%)	P	OR	CI (95%)	P
Mother's age						
< 18 years	5.41	[1.69-17.32]	0.004	2.29	[0.64-8.11]	0.198
18-35 years	1	1	1	1	1	1
>35 years	1.25	[0.64-2.47]	0.505	1.40	[0.54-3.67]	0.483
Study level						
Illiterate	4.21	[1.10-16.06]	0.035	8.74	[1.65-46.08]	0.011
Primary	1.35	[0.33-5.58]	0.672	4.83	[0.79-29.53]	0.088
Middle School	2.65	[0.64-11]	0.179	11.94	[1.89-75.50]	0.008
high school	1	1	1	1	1	1
Socio-economic level						
Low	3.75	[1.17-12.01]	0.026	2.38	[0.59-9.60]	0.222
Medium	2.13	[0.63-7.14]	0.218	1.50	[0.34-6.53]	0.589
High	1	1	1	1	1	1
Parity						
Primiparous	2.17	[1.37-3.44]	0.001	1.72	[0.91-3.27]	0.093
Multipara	1	1	1	1	1	1
Prenatal consultation follow-up						
<4 ANC	6.02	[3.39-10.69]	< 0.001	5.69	[2.74-11.83]	<0.001
≥4 ANC	1	1	1	1	1	1
BMI classes						
≥18.5; 25 <Normal weight	3.49	[1.83-6.83]	< 0.001	3.84	[1.73-8.52]	0.001
≥25; 30 <overweight	1	1	1	1	1	1
≥ 30 obese	0.11	[0.05-0.25]	< 0.001	0.13	[0.05-0.35]	<0.001
Nutrition education						
Yes	1	1	1	1	1	1
No	0.2	[0.10-0.396]	< 0.001	6.22	[2.60-14.87]	<0.001
Tiring domestic activity						
Yes	1.91	[1.21-3]	0.005	2.13	[1.14-3.99]	0.017
No	1	1	1	1	1	1
Psychological support						
Yes	1	1	1	1	1	1
No	2.90	[1.82-4.61]	< 0.001	3.23	[1.72-6.08]	<0.001

OR: odds ratio; CI: confidence interval; ANC: Antenatal consultation; BMI: body mass index

obese [OR: 0.13 (0.05-0.35), P <0.001]; those who have not received nutrition education [OR: 6.22 (2.60-14.87), P<0.001]; women tiring household activity during pregnancy [OR: 2.13 (1.14-3.99), P=0.017] and those with poor psychological support from family and friends [OR: 3.23 (1.72-6.08), P<0.001].

DISCUSSION

Fetal weight is a marker of fetal well-being, it not only makes it possible to estimate - a posteriori - harmonious growth in utero, but it is also

a determining marker of risk of disease in adulthood [10]. In our study, the prevalence of LBW is undefined, and although it would exist, it would be uncertain as there is an under-reporting of the weight of newborns in the birth registry. The mean weight of NW newborns in our study was 3374.04±214.66 and 1955.77±439.94 for LBW newborns, with gestational age of controls being 38.10±0.96 versus 31.66±2.99 for cases. The determinants of the LBW are multiple and intertwined. In this study, several potential risk factors for LBW lost their statistical significance in

multivariate analysis. However, our results showed, after multivariate analysis.

Data from the present study reveal the proportions of infants who are underweight. The frequency of the LBW problem reported by several authors was higher in women with a low education level [11, 19]. Illiterate parturient in the present study ran 8.74 times the risk of giving birth to infants with underweight. Our study also revealed that women with a medium level of education also ran a risk of 11.94. Indeed, many mechanisms can explain the association between the level of education and low birth weight such as the mother's diet, genital infections, the frequency and quality of prenatal care, the mother's stress as well as other psychosocial factors that can influence the successful course of pregnancy [12, 13]. Regarding the follow-up of the antenatal consultation, the results of this study show that parturient who did not follow up or who had insufficient follow-up of ANC were more predisposed to deliver newborns with LBW and that the risk in these women was evaluated at 5.69. This finding is consistent with that reported by other authors who demonstrate that poor pregnancy monitoring hinders the possibility of taking systematic preventive measures against anemia or other nutritional deficiencies and of acting on the curable medical causes of low birth weight [8, 14, 15]. In addition, WHO recommends that nutritional and preventive advice be renewed at each antenatal consultation [16]. However, lack of nutrition education and insufficient ANC during pregnancy were found to be variables strongly associated with low birth weight in this study. Indeed, nutritional status is considered to be a condition resulting from the balance between the ingestion of food and its use by the body. In addition, the multivariate analyzes of this study report a significant association between the BMI of parturient and LBW. This observation confirms the data in the existing literature on BMI and the risk of low birth weight [17, 18]. In the social register, the experience of motherhood is inseparable from the family and community experience. In fact, poor psychological support for the mother by her family and those around her would influence the course of the pregnancy and present a risk of low birth weight in the newborn at birth [19]. In the present study, a strong association was found between psychological support and low birth weight. Another factor examined in this study concerns strenuous household activity during pregnancy. The study by *Traore et al.* [20] and *Dageville* [21] reported that intensive and strenuous work during pregnancy, a large family load with young children are the main determinants of LBW in developing countries. In this study, a significant association between strenuous household activity and low birth weight is well established.

CONCLUSION

The present work reports a link of low birth weight with a combination of factors including the study level, ANC monitoring, BMI classes, nutrition education, strenuous household activity, and poor psychological support. Knowledge of these modifiable factors would allow better organized prenatal follow-up coupled with better health and nutritional education to significantly contribute to reducing the frequency of low birth weight.

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Conflicts of interest

The authors declare no conflict of interest.

REFERENCES

1. *Ashley, J.*: The ninth revision of the International Classification of Diseases: nosology and the specialist in community medicine. *J Public Health*, 1979;1(2): 106-114.
2. *Coutinho, P.R., et al.*: Factors associated with low birth weight in a historical series of deliveries in Campinas, Brazil. *Revista da Associação Médica Brasileira*, 2009;55(6):692-699.
3. Information, C.I.f.H., Too early, too small: a profile of small babies across Canada. 2009: Canadian Institute for Health Information= Institut canadien d'information
4. WHO, UNICEF-WHO low birthweight estimates: levels and trends 2000-2015. World Health Organization. 2019.
5. Unicef, Progrès pour les enfants: Un bilan de la nutrition. 2006: UNICEF.
6. *Nagalo K, Dao F, Tall FH, Yé D.*: Morbidité et mortalité des nouveau-nés hospitalisés sur 10 années à la Clinique El Fateh-Suka (Ouagadougou, Burkina Faso) [Ten years morbidity and mortality of newborns hospitalized at the Clinic El-Fateh Suka (Ouagadougou, Burkina Faso)]. *Pan Afr Med J*. 2013 Apr 20;14:153. French. doi: 10.11604/pamj.2013.14.153.2022.
7. santé, M.d.l., Plan d'action du Maroc pour accélérer la réduction de la mortalité maternelle et néonatale. Fin du compte à rebours 2015;2012-2016
8. *Kangulu, I. B., Umba, E. K. N., Nzaji, M. K. ; Kayamba, P. K. M.*: Risk factors for low birth weight in semi-rural Kamina, Congo Democratic Republic. *Pan Afr Med J*. 2014;17:220-220.
9. WHO, Diet, nutrition, and the prevention of chronic diseases: Report of a Joint WHO/FAO Expert Consultation. World Health Organization, 2003;916.

10. *Reboul, Q.*: Prédiction des enfants petits pour l'âge gestationnel par biométrie fœtale et étude de l'impact du délai échographie-accouchement.2017.
11. *Demelash, H.*, et al. Risk factors for low birth weight in Bale zone hospitals, South-East Ethiopia: a case-control study. *BMC pregnancy and childbirth*, 2015;15(1):1-10.
12. *Garba, M.*, et al. Les déterminants de la mortalité néonatale précoce à la maternité Issaka-Gazobi de Niamey. *J Pédiatrie et de Puériculture*, 2017;30(4):156-161.
13. *Leno, D.*, et al., Les déterminants maternels associés au petit poids pour l'âge gestationnel à la maternité de l'hôpital Donka de Conakry. *Revue de médecine périnatale*, 2017;9(3):178-183.
14. *Hassoune, S.*, et al., Maternal factors associated with low birth weight: case-control study in a Moroccan public hospital. *Pan Afr Med J*. 2015;20:303-303.
15. *Nobile, C.G.*, et al., Influence of maternal and social factors as predictors of low birth weight in Italy. *BMC Public Health*, 2007;7(1):1-9.
16. WHO, WHO recommended interventions for improving maternal and newborn health: integrated management of pregnancy and childbirth. 2007, World Health Organization.
17. *Jafari, F.*, et al., Socio-economic and medical determinants of low birth weight in Iran: 20 years after establishment of a primary healthcare network. *Public Health*, 2010;124(3):153-158.
18. *Shaw, G.M.*, et al., Maternal prepregnancy body mass index and risk of spontaneous preterm birth. *Paediatric and Perinatal Epidemiology* 2014;28(4):302-311.
19. *Mohd Zain, N., W.-Y. Low, and S. Othman*: Impact of maternal marital status on birth outcomes among young Malaysian women: a prospective cohort study. *Asia Pacific J Publ Health*, 2015;27(3):335-347.
20. *Traore, H.*, et al.: Déterminants du faible poids de naissance chez des enfants nés de mères séropositives pour le VIH, non éligibles au traitement antirétroviral, en Afrique. *Revue d'épidémiologie et de santé publique*, 2013;61(5):413-420.
21. *Dageville C.*: Quelles sont les principales causes de naissance prématurée? 1001 bébes, 2007;35-42.

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EVALUATION OF MEMBRANE-DESTRUCTIVE PROCESSES IN RATS WITH INDUCED CARCINOGENESIS OF THE COLON USING THE CITOSTATIC VINCRISTINE

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ABSTRACT

Background. Every year the number of cases of colorectal cancer increases. Chemotherapy is one of the main methods of treating cancer. However, chemotherapeutic treatment of colorectal cancer is inextricably linked to hepatotoxic reactions.

Objective. The aim of this study was to investigate the effect of the cytostatic vincristine on the background of previous enterosorption correction with the drug aut-m in adenocarcinoma of the colon.

Material and methods. To simulate carcinogenesis, dimethylhydrazine (DMH) was administered subcutaneously to 77 rats for 30 weeks at a dose of 7.2 mg/kg body weight. After simulation of colon cancer, the animals were intragastrically administered enterosorbent at a dose of 1 ml of suspension (corresponding to 0.2 g of net weight of the drug) per 100 g of body weight of the animal, daily for 21 days. After detoxification therapy, rats with simulated carcinogenesis were administered the daily cytostatic vincristine at a dose of 0.23 mg/kg for 14 days.

Results. It was found that prolonged administration of dimethylhydrazine is accompanied by destructive changes in plasma membranes, as evidenced by increased activity of enzymes alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, and serum urea.

Conclusions. The used sorbent aut-m showed an effective effect on reducing the manifestations of cytolytic processes in induced carcinogenesis, as indicated by the normalization of the studied parameters. The cytostatic vincristine, which was used in rats with induced colorectal cancer after enterosorption therapy, did not significantly affect the enhancement of cytolytic processes, which confirms the effectiveness of previous sorption measures under these conditions.

Key words: *dimethylhydrazine, colorectal cancer, membrane destructive processes, enterosorbent aut-m*

INTRODUCTION

Colorectal cancer (CRC) is one of the leading causes of cancer deaths in the world, and its incidence is rising in developing countries. According to the International Agency for Research on Cancer, the number of cancer patients worldwide in 2018 was over 18 million. More than 600,000 cases of CRC are reported worldwide each year, and less than a third of these patients live for more than 5 years [16].

One of the main methods in the treatment of cancer is chemotherapy. However, toxic side effects of chemotherapy components can sometimes lead to discontinuation of treatment before a clear antitumor effect is obtained [8]. Chemotherapy for cancer in some patients is accompanied by a hepatotoxic reaction,

which may progress both during treatment and in between courses or after their completion. Violation of the integrity of plasma membranes of hepatocytes indicates the development of fatty degeneration, hepatocellular necrosis and fibrosis, the appearance of duct disorders with cholestasis, changes in the activities of aminotransferases, alkaline phosphatase [3]. Liver damage as a side effect can be observed with the use of almost all groups of cytostatics.

Finding effective remedies to alleviate the side effects of anticancer drugs is an extremely important problem in medicine [8]. There is information in the literature on the effectiveness of the use of sorbents in the therapeutic support of cancer patients. Analyzing the results of many years of study of the mechanisms of action of enterosorbents, we can conclude that

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the fibrous, carbon sorbent AUT-M deserves special attention [13, 14]. The drug itself consists of micro-, meso- and macropores and has a specific pore surface area of about 2000-2500 m²/g, which allows to absorb a wide range of substances of different molecular weight [9,10].

The aim of this work was to study the effect of the cytostatic Vincristine on the background of previously performed enterosorption correction with the drug AUT-M in adenocarcinoma of the colon.

MATERIALS AND METHODS

Materials

Studies were performed on 77 white male rats weighing 200–250 g. Laboratory animals were kept on a standard diet of the vivarium of Horbachevsky Ternopil National Medical University in accordance with the rules of the European Convention for the Protection of Vertebrate Animals Used for Scientific and Other Scientific Purposes. The study was approved by the Ethics Commission of the Horbachevsky Ternopil National Medical University Gorbachevsky (Excerpts from the protocol №61 from 13.11.2020).

Scheme of experimental research

Adenocarcinoma of the colon in rats was simulated by subcutaneous administration of the carcinogen 1,2-dimethylhydrazine (DMH) (Sigma-Aldrich Chemie, Japan), pre-diluted with saline in the interscapular region at a dose of 7.2 mg / kg [2, 5, 6].

DMH was administered once a week for 7 months. After modeling the cancer process, the animals underwent detoxification correction with the sorbent AUT-M. The sorbent was administered intragastric daily for 21 days. The daily dose of sorbent was 1 ml of suspension (corresponding to 0.2 g of net weight of the drug) per 100 g of body weight of the animal.

The next step was cytostatic correction with Vincristine. Vincristine was administered for 14 days, intragastric at a dose of 0.23 mg/kg daily, the dose was recalculated according to *Rybolovlev*, taking into account species sensitivity [12].

Rats were divided into three groups: I - control animals, which were injected with saline subcutaneously in the interscapular area once a week for 30 weeks; II - animals with simulation of adenocarcinoma of the colon; III - animals with imitation of adenocarcinoma of the colon and 21-day extracorporeal detoxification with sorbent AUT-M; IV - animals with simulated carcinogenesis of the colon, which after 21 days of enterosorption correction were administered for 14 days cytostatic Vincristine.

Animals were removed from the experiment once a month for 7 months, on the 14th and 21st day of administration of the enterosorbent AUT-M, as well

as on the 14th day of administration of the cytostatic Vincristine. All manipulations were performed under thiopental anesthesia.

Methods

Blood and liver samples were used in subsequent studies. Blood was taken from the hearts of animals. To obtain serum, blood samples were allowed to coagulate (at room temperature for 30 min), then centrifuged for 15 min at 1200 g and room temperature. To prepare 10% liver homogenate, samples taken immediately after euthanasia were cooled to 1-3 ° C in saline, dried on filter paper and homogenized in 0.05 M Tris-HCl buffer (pH 7.4) using a SilentCrusher S magnetic homogenizer (Haydolph, Germany).

The intensity of membrane-destructive processes in the liver was assessed in serum and liver homogenate by the activity of enzymes aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and urea content [19]. Enzyme activity was determined by turbidimetric method using a semi-automatic biochemical analyzer Humalyzer 2000 using a colorimetric set of reagents Human (Germany).

Statistical analysis of the data was performed using STATISTICA 13 (TIBCO Software Inc., 2018). Parametric and non-parametric methods of evaluation of the obtained data were used for statistical processing of the results. The arithmetic mean of the sample (M) and the error of the arithmetic mean (m) were calculated for all indices. The reliability of the difference between the values between the independent quantitative values was determined by the normal distribution using *Student's* t-test, in other cases by the *Mann-Whitney* test. The difference between the values was considered probable at $p < 0.05$.

RESULTS

It is known that the development of a malignant process is accompanied by impaired liver function, in particular, changes in the permeability and structure of hepatocytes [5, 6].

Changes in the activity of membrane-dependent enzymes, such as aminotransferases, have been revealed in the dynamics of modeling DMH-induced carcinogenesis. Thus, after 1 month of DMH administration, ALT activity in the serum of affected rats probably ($p < 0.05$) increased by 36%, on the 4th month by 56% compared with the activity of this enzyme in animals of the control group (Figure 1). In the following terms of the study there was a slight decrease in ALT activity compared to previous terms (5 months - the activity of the enzyme was only 42% higher than the level of control animals, 7 months - 25% higher than their level).

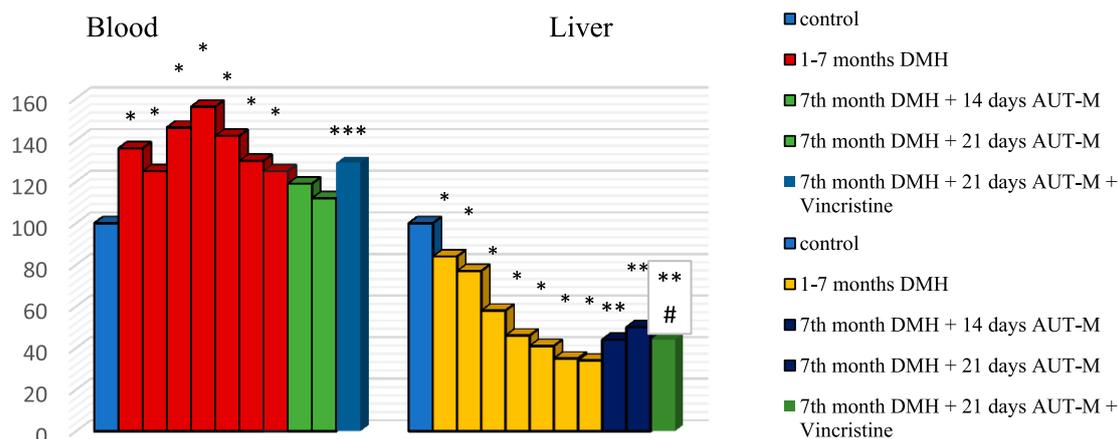


Figure 1. Dynamics of changes in ALT activity in the serum and liver of rats with induced carcinogenesis after the use of cytostatics on the background of previous detoxification

Note: here and in the following figures * - probable changes between the indicators of the animals of the control group and those affected by DMH; ** - probable changes between the rates of carcinogenic animals and animals that received enterosorbent; *** - probable changes between the rates of carcinogenic animals after enterosorption therapy (21 days) and animals receiving cytostatics (14 days); # - probable changes between carcinogenic animals (7 months) and animals receiving cytostatics (14 days) on the background of enterosorption therapy (21 days)

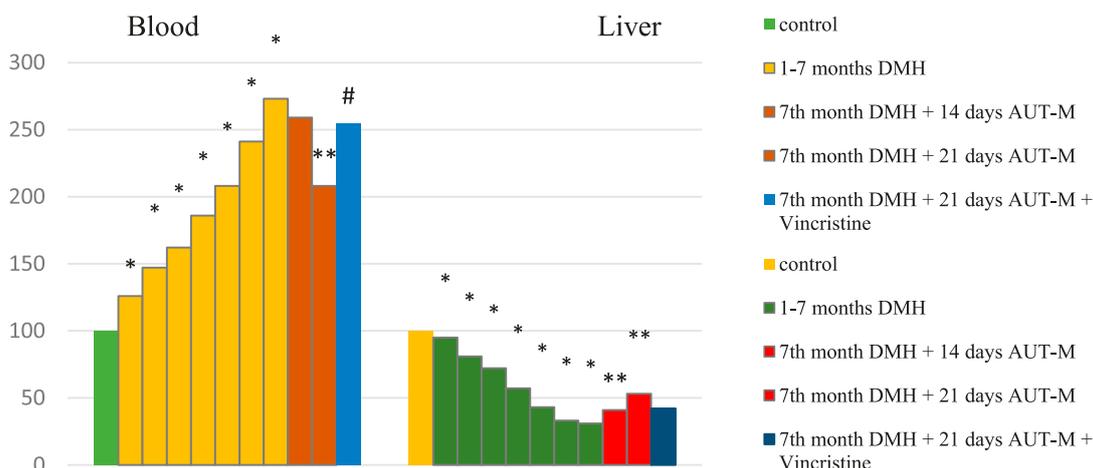


Figure 2. Dynamics of changes in the activity of AST in the serum and liver of rats with induced carcinogenesis after the use of cytostatics on the background of previous detoxification

In contrast, in the liver at all times of the experiment there is a probable progressive decrease in this indicator (3 months - by 42%, 5 months - by 59%, 7 months - by 66%) relative to the control group of animals ($p < 0.05$) Figure 1.

Similar changes were recorded in the study of the activity of the enzyme AST. After the 3rd month of modeling carcinogenesis, the activity of the studied indicator in the serum increased by 62%, at 5 months - by 107%, at 7 months - by 172% compared with the control animals Figure 2.

On the other hand, the activity of the AST enzyme in the liver homogenate significantly ($p < 0.05$) decreased by 28%, 57%, 69% compared with control animals in the corresponding terms of the study (Figure 2).

In animals that underwent a course of detoxification, there was a decrease in the manifestation of cytolytic

syndrome. At 21 days of AUT-M administration in rats with carcinogenesis, there was a tendency to reduce the activity of AST in serum (by 65% relative to the level of affected animals) compared with the group of animals that were injected with carcinogen for 30 weeks. Restoration of enzyme activity in the liver of animals after 21-day extracorporeal detoxification (16% ALT, 22% AST) was also observed in comparison with the group of animals with DMH-induced cancer.

On the 14th day of cytostatic action in animals with simulated carcinogenesis on the background of enterosorption, minor changes in the activity of the studied enzymes in the direction of decreased activity in liver homogenate (ALT - by 10%) and increase in serum (ALT - by 17%, AST - by 18%).

During the simulation of carcinogenesis, a progressive increase in ALP activity in the serum

of DMH-affected rats was found compared to control animals.

Thus, the activity of ALP increased in the serum of DMH-affected animals: 1 month after carcinogen administration by 46%, 3 months - by 114%, 5 months - by 127%, 7 months - by 129% Figure 3. All changes were probable ($p < 0.05$).

In the liver homogenate, the activity of this enzyme probably decreased by 18% in 1 month of the experiment, by 5 months - by 50%, by 7 months - by 61% according to the control (Figure 3).

After application of the sorbent AUT-M for 21 days, the activity of ALP in the serum of affected rats probably decreased ($p < 0.05$) by 22%, in liver homogenate increased by 18% (Figure 3) compared with the group of animals from DMH-induced carcinogenesis.

The use of the cytostatic Vincristine on the background of 21-day correction with enterosorbent has little effect on changes in ALP activity. Thus, in the serum this figure increased by 21% compared with the group of DMH-affected rats after in vitro detoxification. In contrast, in the liver homogenate, ALP activity decreased slightly.

It was found that in the serum of animals with induced adenocarcinoma of the colon urea content probably ($p < 0.05$) increased in all terms of the experiment (2 months - 1.1 times, 3 months - 1.2 times) relative to control indicators Table 1.

The maximum changes were observed after 4 months (increased 1.6 times) from the beginning of the modeling of the oncological process. In the subsequent terms of the experiment, this figure in the affected

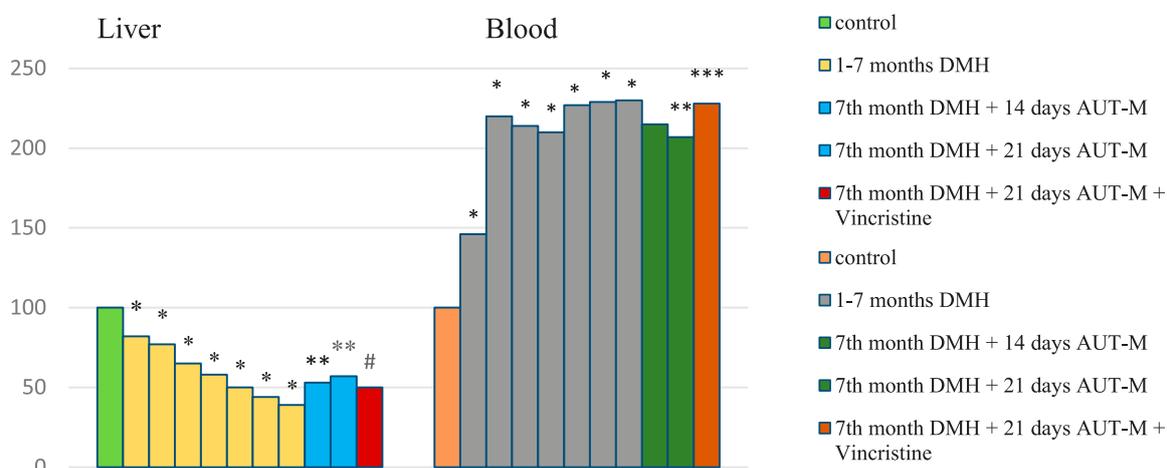


Figure 3. Dynamics of changes in the activity of ALP in the serum and liver of rats with induced carcinogenesis after the use of cytostatics on the background of previous detoxification

Table 1. The content of urea in the serum of rats with induced cancer and after the use of enterosorbent AUT-M and cytostatics Vincristine ($M \pm m$)

Investigated indicator / Group of animals, term of affection	Urea, (mmol / l)
Control, n=7	40.96±1.11
1 Month, n=7	40.48±0.46
2 Month, n=7	47.00±0.85*
3 Month, n=7	49.08±0.53*
4 Month, n=7	51.68±0.76*
5 Month, n=7	46.13±0.78*
6 Month, n=7	46.09±0.84*
7 Month, n=7	45.91±0.62*
7 month DMH + AUT-M (14 days), n = 7	44.83±0.27
7 month DMH + AUT-M (21 days), n = 7	44.02±0.35
7 months DMH + AUT-M (21 days) + Vincristine (14 days), n = 7	46.35±0.55***

Note: * - probable changes between the indicators of animals of the control group and those affected by DMH; *** - probable changes between the rates of carcinogenic animals after enterosorption therapy (21 days) and animals receiving cytostatics (14 days).

animals decreased, but continued to exceed the level of the control group.

Extracorporeal detoxification with the drug AUT-M in the group of rats with induced chronic endotoxemia is accompanied by normalization of urea content (without probable changes).

The use of the cytostatic Vincristine in animals with simulated carcinogenesis on the background of detoxification therapy contributes to a slight increase in urea content compared to a similar figure in the group of affected DMH animals on the background of 21-day detoxification.

DISCUSSION

It is known from the literature that the metabolism of the carcinogen DMH occurs in the liver. Accumulation of endogenous toxins formed during DMH metabolism becomes a trigger to change the permeability of hepatocyte plasma membranes, which is why the liver is most toxic in the early stages of carcinogenesis modeling [1, 18].

Aminotransferases are intracellular enzymes that are mainly deposited in the cytoplasm of hepatocytes, so their content in the serum is normally low [17]. According to our research, the simulation of DMH-induced carcinogenesis of the colon is accompanied by an increase in the activity of the studied enzymes in serum and a decrease in their activity in the liver in the early stages of cancer [4, 20, 21]

After 4 months of DMH administration, changes in aminotransferase activity in the studied tissues are less pronounced. Such data, in our opinion, may indicate a gradual decrease in the number of destroyed hepatocytes due to compensatory processes in the liver [17].

The hyperenzymemia we have identified indicates hepatocellular liver damage and the release of liver enzymes into the blood. An informative indicator of membrane destruction of hepatocytes is ALP. The rapid increase in the activity of the organ-specific enzyme ALP, which is localized mainly in the biliary tract, during the simulation of colon adenocarcinoma is, in our opinion, a consequence of inflammatory processes and liver cholestasis, as reported in the literature [15].

Elevated urea levels also indicate changes in liver function. Urea is the end product of protein metabolism, the content of which in the serum of experimental animals depends on the intensity of its synthesis and excretion [11]. After 30 weeks of DMH administration, the serum urea content of the affected animals increased by 12% relative to the control rat group. These data may indicate an increase in protein breakdown and the inability of the liver and kidneys to ensure inactivation and timely excretion of toxins.

Enterosorbent AUT-M reduces the load on the main organs of metabolism and detoxification (liver) and, accordingly, helps to activate the endogenous defenses of the body. The activity of the enzymes ALT, AST, ALP in the serum decreases, while in the liver - probably increases. Therefore, the sorption correction helps to stabilize the functional state of the liver.

It is believed that chemotherapy of malignant tumors is a drug-induced critical condition of the body, because all chemotherapeutics are poisons that are used to obtain cytoreductive, cytostatic or cytoeliminative effect. A number of authors note that hepatocytes are the most sensitive to chemotherapy. Under the action of cytostatics, the integrity of the plasma membranes of liver cells is violated, as a result of progressive cell-hepatic failure and cytolysis of hepatocytes [7, 11].

According to the results of our studies, the introduction of the cytostatic Vincristine on the background of 21-day use of enterosorbent did not lead to significant changes in the studied parameters. After 14 days of chemotherapy, the activity of ALT and AST in serum increased by 17% and 18%, respectively, in the liver, the activity of enzymes decreased compared to those in the group of animals with induced adenocarcinoma. Since the level of aminotransferase activity correlates with the degree of hepatocyte damage, the results obtained may indicate minor destructive changes under the influence of cytostatic correction against the background of the sorbent.

CONCLUSION

DMH-induced carcinogenesis of the colon in rats is accompanied by changes in the functional state of the liver, as indicated by an increase in urea in the serum of rats during seven months of modeling the cancer process. Increased activity of aminotransferases and alkaline phosphatase in serum and a decrease in these parameters in the liver of animals with a simulated cancer process indicates the development of cytotoxic syndrome and cholestasis.

In order to reduce the side effects of the cytostatic Vincristine, the enterosorbent AUT-M was used. The use of the sorbent has shown a significant potential for cytolysis inhibition in rats with DMH-induced colon carcinogenesis. Cytostatic correction after 21 days of extracorporeal detoxification indicates minor manifestations of cytotoxic syndrome. The results confirm the positive effect of enterosorption in the development of carcinogenesis before the use of cytostatics and may serve as a basis for further study of the possibility of enteral sorption therapy in patients with colorectal cancer to reduce side effects of chemotherapy and alleviate the disease.

Conflicts of interest

The authors report no financial or any other conflicts of interest in this work.

REFERENCES

1. *DE-Souza ASC, Costa-Casagrande TA.*: Animal models for colorectal cancer. *Arq. Bras. Cir. Dig*, 2018;31(2): e1369. DOI: 10.1590/0102-672020180001e1369
2. *Deryagina VP, Ryzhova NI, Razin AN.*: Experimental study of the effect of *Lentinus Edodes* (Shiitake) on tumor growth in mice on models of transplantation and chemical carcinogenesis. *Russian Journal of Oncology*, 2009;1:33–38.
3. *He HW, Wang NN, Yi XM, Tang CP, Wang D.*: Low-level serum miR-24-2 is associated with the progression of colorectal cancer. *Cancer Biomark*, 2018;21(2):261-267. DOI: 10.3233/CBM-170321
4. *Huang XJ HS, Yarimaga O, Yoon E, Kim HS.*: Aspartate Aminotransferase (AST/GOT) and Alanine Aminotransferase (ALT/GPT) Detection Techniques. *Sensors (Basel)*, 2006;6(7):756–782. <https://doi.org/10.3390/s6070756>
5. *Kachur O, Fira L, Lykhatskyy P, Fira D, Kramar S.*: State of humoral immunity, cytokine status in rats under experimental carcinogenesis and applying enterosorption and chemotherapeutic factors. *Polski Merkuriusz Lekarski*, 2020;288:35–39.
6. *Kachur O, Fira L, Lykhatskyy P, Fira D, Stechyshyn I.*: The state of pro- and antioxidant systems in rats with DMH-induced colon carcinogenesis on the background of extracorporeal detoxification. *Pharmacia*, 2021; 68: 941. <https://doi.org/10.3897>
7. *Keshet R, Szlosarek P, Carracedo A, Erez A.*: Rewiring urea cycle metabolism in cancer to support anabolism. *Nat Rev Cancer*, 2018; 18(10): 634-645. DOI: 10.1038/s41568-018-0054-z
8. *Madsen ML, Due H, Ejksjer N, Jensen P, Madsen J, Dybker K.*: Aspects of Vincristine-Induced Neuropathy in Hematologic Malignancies: A Systematic Review *Cancer Chemother Pharmacol*, 2019;84:471-485. DOI: 10.1007/s00280-019-03884-5
9. *Mikhailovsky S., Sandeman S., Howell C., Phillips G., Nikolaev, V.*: Biomedical Applications of Carbon Adsorbents. In *Novel Carbon Adsorbents, 2012; 21: 639-669*. <https://doi.org/10.1016/B978-0-08-097744-7.00021-1>
10. *Nikolaev VG, Sakhno LA, Snezhkova EA, Sarnatskaya VV, Yushko LA.*: Carbon adsorbents in oncology: achievements and perspectives. *Experimental Oncology*, 2011;33(1):2–8.
11. *Omnia Abdel-Hamid M, Abeer AN, Emam, MA, Elshimaa, MA.*: The ameliorative effect of Vitamin C in experimentally induced colon cancer in rats. *Benha veterinary medical journal*, 2018;34(1):329-343.
12. *Rybolovlev YuR.*: Dosing of substances for mammals according to the constants of biological activity. *Reports of the Academy of Sciences of the USSR*, 1979;247(6):1513-1516.
13. *Sakhno LA, Bardakhivska KI, Maslenny VN.*: Experimental study of some treatment effects of oral adsorption. *Ukrainian Journal of Modern Problems of Toxicology*, 2014;1:64–65.
14. *Sakhno LA, Yurchenko OV, Maslenny VN, Bardakhivskaya KI, Nikolaeva VV, Ivanyuk AA, Shevchuk OO, Korotich VG.*: Enterosorption as a method to decrease the systemic toxicity of cisplatin. *Experimental Oncology*, 2013;35(1):45–52.
15. *Scheipner L, Smolle MA, Barth D, Posch F, Stotz M, Pichler M, Stöger H, Gerger A, Riedl JM.*: The AST/ALT Ratio Is an Independent Prognostic Marker for Disease-free Survival in Stage II and III Colorectal Carcinoma. *Anticancer Research January 2021;41(1):429-436*. DOI: 10.21873/anticancer.14792
16. *Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Bray F.* *Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 CA: Cancer Journal for Clinicians*, 2021;71(3):209–249. DOI: 10.3322/caac.21660
17. *TAarrant J, Meyer D, Katavolos P.*: Use of optimized aminotransferase methods in regulated preclinical studies. *Technical report*, 2013;42(4):535-538. DOI: 10.1111/vcp.12082
18. *Venkatachalam K, Vinayagam R, Arokia Vijaya Anand M, Isa NM, Ponnaiyan R.*: Biochemical and molecular aspects of 1,2-dimethylhydrazine (DMH)-induced colon carcinogenesis: a review. *Toxicol Res (Camb)*, 2020;9(1):2-18. DOI: 10.1093/toxres/taaa004
19. *Vlizlo VV, Fedoruk RS.*: Laboratory methods of investigation in biology, stock-breeding and veterinary. *Reference book*. Spolom, Lviv: 2012;764
20. *Wang H.*: MicroRNAs and Apoptosis in Colorectal Cancer. *Int J Mol Sci*, 2020;28;21(15):5353. doi: 10.3390/ijms21155353
21. *Yu C, Wen XD, Zhang Z, Zhang CF, Wu XH, Martin A, Du W, He TC, Wang CZ, Yuan CS.*: American ginseng attenuates azoxymethane/dextran sodium sulfate-induced colon carcinogenesis in mice. *J. Ginseng. Res*, 2015;39(1):14-21. DOI: 10.1016/j.jgr.2014.07.001

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THE EFFECT OF LAYING DOWN POSTURE WHILE USING SMARTPHONE AMONG SCHOOL CHILDREN IN NAKHON SI THAMMARAT, THAILAND

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ABSTRACT

Background. Lots of children use the smartphone in lying down posture that is unappreciated posture. The postures of children while using a smartphone affect their musculoskeletal pain and can enhance Musculoskeletal Disorders (MSDs). **Objective.** To study the effect of lying down posture while using smartphone among school children in Nakhon Si Thammarat, Thailand.

Materials and methods. This survey study employed a Descriptive Cross-Sectional Design. The population was Grade 1-6 students studying in a primary school in Nakhon Si Thammarat. There were 122 samples selected based on the Volunteer Sampling Technique under the written consent of the students' guardians. The research instruments employed in this study were: 1) Questionnaire adapted from Nordic Musculoskeletal Questionnaire asking musculoskeletal symptoms, 2) Posture Assessment using Kinovea Software to measure the angles of the muscle and postures during photo and video shooting of the smartphone users. The data were analyzed using descriptive statistics while Chi-square and Mann-Whitney U tests were used to test the mean differences.

Results. There is a significant difference at $p < 0.05$ level in mean angles of the neck, trunk, shoulder, and lower arms when using smartphones in supine and prone postures. The correlation between smartphone usage postures and musculoskeletal symptoms at the head/neck, trunk, and upper arm are found significantly different at $p < 0.05$ level. The statistically significant difference at $p < 0.05$ level is also found in the differences of age, length of smartphone ownership, position when using smartphone, and length of a smartphone usage in lying down positions.

Conclusion. Smartphone usage in lying down positions of the participants can cause musculoskeletal pain especially in prone posture. It is recommended that guardians or relevant sectors have greater attention to smartphone usage among children to prevent their long-term musculoskeletal problems.

Key words: *lying down posture, smartphone, students*

INTRODUCTION

Nowadays, learning and acquiring knowledge is not limited only from textbooks or printed materials but technology also plays an important role in several aspects of our daily lives. People learn more from technology anytime and anywhere. Technology usage has been vastly introduced into classroom learning, especially during the epidemic situation of COVID-19. The form of teaching and learning has been changed into an online learning approach. Therefore, the smartphone is an important device for learners to promptly access online learning in the current

situation. It was reported that the percentage of global smartphone use during the Covid-19 outbreak among Gen Z (those who were born after 1997) was 82%, whereas the Gen Baby boomers were only 43% [1]. In Thailand, a survey of smartphone usage revealed that the group of children and youths was the majority of smartphone users at the highest frequency (CD) and 73.9% of internet use was performed by children aged between 6-14 years [2]. Prolonged smartphone usage can cause several aspects of health problems such as eyesight, behavioral sleep problems [3, 4] mental health [5], specific problems in musculoskeletal pain caused by faulty positions during smartphone usage.

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Numerous research studies reported that smartphone usage can cause MSDs problems affecting the head, neck, trunk, upper- and lower-limbs. The prolonged usage of smartphones with continual neck flexion can lead to an improper posture of the head at 33–45° flexion (50th percentile angle) from vertical when using smartphones [6]. The muscle activity level of smartphone users with neck pain is slightly higher than those without neck pain [7]. An increase in the duration of upper back flexion can cause thoracic kyphosis [8]. When excessive thoracic kyphosis occurs, (>40° kyphosis) it will lead to neck and back pain [9]. Moreover, overuse of smartphones can result in tenosynovitis [10].

The finding in a smartphone usage survey among primary school students in Nakhon Si Thammarat indicated that the students vastly used smartphones in their daily lives. The characteristic postures of smartphone use are in different positions such as sitting, standing and, lying down. Furthermore, it was found from the student interview that the most common posture used is lying down position by reason of more relaxation and a longer period of usage than sitting position. According to *Mateus* et al. [11] who conducted the study of different characteristic postures e.g. desk sitting, sitting cross-legged, lying supine, lying prone and standing when using the computer, tablet, and smartphone among 5-year children, it was reported that sitting on a desk and standing positions are the safest postures, on the other hand, the greatest risk of the affected area is on neck-trunk. Moreover, it was found that the most affected areas of lying prone are neck and trunk, and for lying supine are the arm and wrist [12]. Several researchers reported a number of studies of smartphone usage among children, however, there are few studies on investigating the lying postures and their effects on the musculoskeletal system of smartphone users in that the lying position is a greater effect on muscle fatigue or discomfort than the sitting posture [13]. Specifically, the studies on smartphone usage among elementary school children are utterly limited. Additionally, a current problem of smartphone usage among children is increased and it can lead to short- and long-term effects on their musculoskeletal conditions. Therefore, the researchers were encouraged to examine the lying postures of smartphone users and their short-term effects of musculoskeletal pain on elementary school children in Nakhon Si Thammarat, Thailand.

MATERIALS AND METHODS

Study Design

This study employed a Descriptive Cross-Sectional Design. The population was Grade 1-6 students studying at a primary school in Nakhon Si Thammarat,

Thailand. This study had been conducted under the official consent of Walailak University Human Research Ethics Committee no. WUEC-19-061-01.

Population and Samples

The population was Grade 1-6 students studying in an elementary school in Nakhon Si Thammarat who used a smartphone in lying postures for a period of at least 6 months. There were 122 samples selected based on Volunteer Sampling Technique. All research subjects were informed of the research participation under the written consent of their guardians.

Posture Assessment

The body postures were assessed using Kinovea Software with a validity of 0.79 and reliability of 0.99 [14] to measure the angle of muscles and postures during photo and 5-minute video shootings of smartphone users in lying positions. The assessment was conducted in 4 parts comprising head/neck, shoulder, trunk, and lower arms. Generally, flexion is elevation paralleling to the sagittal plane and abduction is an elevation in the frontal plane [15]. The details of measurement were adopted from research studies [13] on the following angle measurement definitions:

Neck — the neck segment (ear to shoulder) was defined as flexed if the ear was anterior to the shoulder marker, and extended if posterior (A).

Trunk — the trunk segment, an angle was considered flexed if the acromion process (shoulder) was anterior to the greater trochanter (hip), and extended if posterior and a horizontal plane in the prone position (B).

Upper arm — shoulder (glenohumeral), elevation was calculated as the angle between the upper arm upwards away from trunk segment (C). Shoulder internal rotation was calculated as the angle between the forearm segment and a sagittal reference plane (D).

Lower arm — elbow flexion/extension (inner elbow angle), and wrist flexion/extension was considered. Elbow flexion was defined as the angle between the forearm and upper arm (E). Wrist flexion was defined as the angle between the hand (F) segment and the forearm segment (sagittal plane). As shown in Figure 1 and Figure 2.

Musculoskeletal Pain

The questionnaire was designed to ask musculoskeletal pain that appeared on 4 parts of organ namely head/neck, trunk, upper arms (shoulder) and lower arms. The frequency of pain within the past six months was divided into five levels: *never*, *once in a month*, *once in a week*, *more than one time per week*, and *frequently in a week*. If the frequency of musculoskeletal pain appears over one time in a week, it can be interpreted according to Nordic



Figure 1. The posture assessment in the supine position



Figure 2: The posture assessment in the prone position

Musculoskeletal Questionnaire [16] that a student has a short-term effect of musculoskeletal pain.

Data analysis

This study utilized descriptive statistics to analyze the collected data in the aspects of smartphone usage, ergonomic risks, and frequency of musculoskeletal pain. The data were analyzed using frequency, percentage, mean, standard deviation, maximum and minimum values in inferential statistics, t-test for the analysis of the differences of mean angles, and p-value (below 0.05 were considered as statistically significant). The software used for statistical analysis was Microsoft Excel and SPSS version 21.

RESULTS

General information

The majority of the subjects were female students (65.6%) with an average age of 10.19 ± 1.63 years old, 88.5% of them had no congenital disease, 89.3% of the students worked out regularly, 81.1% used their own smartphone, and an average length of smartphone use was 40.4 ± 20.8 minutes per time, or 137.34 ± 97.3

minutes per day. The most common size of smartphone use was 5.5 inches, 77.0% of parents set a rule for smartphone usage, and supine was the most common posture used during smartphone playing (68.0%).

Body Posture When Using a Smartphone

There are two lying down postures of the smartphone users—supine and prone with the following details of body postures.

Supine posture: The body angles of 82 smartphone users on supine position are as the following details:

Head/neck and Trunk: Head/neck is supported by a pillow. The angle of head/neck and trunk are paralleled to the floor. The body is symmetric aligned and sagittal reference plane is aligned.

Upper Arm: The shoulder movement was observed. Most of students have an average angle at 11.66 ± 17.98 degrees of shoulder horizontal abduction. Forty percent (40%) of which has shoulder flexion at 22.84 ± 20.20 degrees while using smartphones.

Lower Arm: There is 100% of smartphone users having elbow flexion at an average angle of 64.40 ± 25.63 degrees, and 41.5% of them performed wrist radial deviation at 14.81 ± 14.3 degrees.

Lying prone posture: The body angles of 40 smartphone users on prone position are as the following details:

Neck: It was found that 100% of the subjects perform neck extension at an average angle of 18.97 ± 13.46 degrees.

Trunk: The trunk extension at a median angle of 19.87±14.44 degrees is also observed in all smartphone users (100%).

Upper Arm: For the upper arm angle, the smartphone users have elevated their upper arms with elbow supported or shoulder elevation at a median angle of 49.46 ± 41.67 degrees.

Lower Arm: Considering the lower arms, the smartphone users have flexed their lower arms to the trunk with elbow flexion. The average angle is 58.08± 44.29 degrees, and 57.5% of the subjects perform wrist

radial deviation at an average angle of 27.25±23.81 degrees.

Comparison of the mean angles differences of the body parts while using smartphones in lying down postures (n=122)

As shown in Table 1, the difference of mean angles of neck, trunk, upper arm (shoulder) in lying supine and prone postures while using smartphones was statistical significance (p<0.05).

Musculoskeletal pain appeared on various parts of body

There are 66.4% of smartphone users have a short-term effect on their musculoskeletal pain. The most common musculoskeletal pain found when using a smartphone in lying supine is at the lower arms

Table 1. Mean angles of body parts when using smartphones in lying postures

Body parts flexion/extension	Posture (Mean ± SD)		p-value
	Supine	Prone	
Head/Neck	8.43±9.69	18.97±13.44	0.000*
Trunk	4.70±5.97	19.87±14.44	0.000*
Upper arm (shoulder)	11.66±17.98	49.46±41.67	0.000*
Lower arm	64.40±25.63	58.08±44.29	0.471

*p<0.05

Table 2. Musculoskeletal pain of various parts of the body (n=122)

Posture	Head/neck		Trunk		Upper arm		Lower arm	
	have	no	have	no	have	no	have	no
Supine	7(5.7)	76(62.3)	11 (9.0)	72(59.0)	29(23.8)	54(44.3)	42(34.4)	41(33.6)
Prone	33(27.0)	6(5.0)	30(24.6)	9(7.4)	31(25.4)	8(6.5)	16(13.1)	23(18.9)
p-value	0.000*		0.000*		0.000*		0.323	

Table 3. Comparison between different factors and durations while using smartphone in lying postures

Factor	Duration in lying posture mean±SD (min)	p-value ^a
<i>Gender</i> Male Female	141.8±98.11 146.8±95.37	0.430
<i>Age</i> ≤ 10 years old >10 years old	121.9±93.72 168.2±93.22	0.001*
<i>Smartphone ownership</i> No Yes	107.7±59.44 153.7±100.84	0.047*
<i>Family agreement on smartphone use</i> No Yes	174.0±120.18 134.6±84.22	0.081
<i>Postures using smartphone</i> Supine Prone	128.5±77.46 180.3±120.40	0.007*

*p < 0.05, ^a. Mann-Whitney U test

(34.4%), followed by the upper arms (23.8%). In a lying prone posture, the musculoskeletal pain at head/neck, trunk, and upper arms are greater than lying supine posture. The most common pain when using the lying prone posture are found at head/neck, upper arms, and trunk (27.0%, 25.4% and 24.6% respectively). The correlation between postures and pain at head/neck, trunk, and upper arms is statistically significant ($p < 0.05$). As shown in Table 2

Comparison of the differences between factors and durations of smartphone use in lying postures

As shown in Table 3, the difference of factors and lengths when using smartphone in lying postures is statistically significant ($p < 0.05$). Different factors of age, smartphone ownership, smartphone usage posture, musculoskeletal symptom have different lengths of smartphone usage in lying positions.

DISCUSSION

Smartphone use in lying postures

Head/Neck

When using a smartphone in lying supine posture, head/neck and neck of smartphone users are paralleled to the axis of body symmetry. There is low-risk head/neck and trunk pain when using lying supine posture, specifically when head/neck is supported by a pillow. Whereas in a lying prone posture, all smartphones users have neck extensions. According to ISO 11226:2000 on Ergonomics-Evaluation of static working postures [17], over 25° neck extension is unacceptable as neck extension is found to correlate with the frequency of neck pain [18]. When texting on a smartphone, muscle activity in the neck-shoulder area of the users has increased resulting in musculoskeletal pain [19]. In this study, the student participants used their own smartphones; the duration of smartphone use is highly possible to be prolonged so that it is probably elevated smartphone users' long-term neck pain and become symptomatic adults.

Trunk

When using smartphones in lying supine posture, trunks of smartphone users and sagittal reference plane are paralleled to the floor. Whereas in lying prone posture, all the smartphones users have trunk extension. In this case, back chronic pain can be a long-term symptom. An imbalance in trunk muscle strength, i.e., extensor muscle strength is lower than flexor muscle strength; it might be one risk factor for low back pain [20]. According to the study of Steffen, it was found that all conditions in extension/flexion relating to lower trunk peak torque cause back pain. Moreover, EMG amplitudes were increased for BP athletes with statistically significant differences for

dorsal muscles in rotation and extension ($p < 0.0042$) [21]. From behavioral observation, while the students were playing with smartphones, it was found more back extension when they were playing games or enjoying interesting stuff in front of them. Sometimes they used elbows to support the trunks demonstrating utmost intention and concentration to use smartphones. It is congruent with *Hanphitakphong* et al. [22] who found that as the time participants spent playing the smartphone game increased, the trunk angle of the participants is greater ($p < 0.05$). The trunk angle of participants was approximately 14.05 ± 11.93 degrees at the start of the game, by the time passed, the angle was increasing to 19.83 ± 13.59 degrees (at 10 minutes) ($p < 0.05$), and 23.15 ± 15.61 degrees (at 20 minutes) ($p < 0.05$), respectively.

Upper arm

Lying supine playing a smartphone, shoulder horizontal abduction and shoulder flexion have been performed. As in the lying prone, the student participants elevated their upper arms with elbow support or shoulder elevation. In the study of fatigue of shoulder muscles at different cervical flexion angles (0° , 30° , and 50°) measured by electromyography, the result revealed that the right upper trapezius (RtUT), left upper trapezius (LtUT) showed the highest muscle fatigue at a cervical flexion angle of 50° and the lowest fatigue at an angle of 30° [23]. Similarly, a study conducted by *Straker* et al. [24] concluded that children who use tablets have greater trunk flexion with more shoulders flexion and elevation compared to desktop computer usage.

Lower arm

Elbow flexion is commonly found in lying supine and prone postures during smartphone playing. This is due to while playing smartphones, the participants compulsorily elevate their elbows to make it more convenient and clear on smartphone screen watching. As a result of this, lying supine playing a smartphone causes muscle tension as the participants have to upraise their elbows. Prolonged smartphone use can cause muscle fatigue and pain. This condition can be explained that during elbow flexion, the stretch of the ulnar nerve is 4.5 to 8 mm since it lies posterior to the axis of motion of the elbow and the cubital tunnel cross-sectional area narrows by up to 55%, as intraneural pressures increase up to 20-fold. As a result, recurrent and constant elbow flexion can irritate the ulnar nerve and finally lead to cubital tunnel syndrome [25]. More findings on the lower arm effect showed that wrist radial deviation has been found in both lying supine and prone postures as the participants would have more convenient to type and play games. The range of wrist postures is inclusive of wrist angles that is

associated with low carpal tunnel pressure and is much lower than the angle (32.7°) that is correlated with high carpal tunnel pressure (more than 30 mm Hg) and it is a high-risk symptom of a carpal tunnel syndrome [26].

Comparison of mean angle differences of various body parts while using smartphones in lying postures

The finding from this study revealed that the differences of mean angles of head/neck, trunk, and upper arms were found statistically significant in lying supine and prone postures. When playing smartphones in a lying prone position, the mean angle of head/neck and trunk is higher than the supine posture. Whereas in a lying supine position, the mean angle of upper arms is greater than the prone one. It can probably explain that when the student participants play smartphones in the supine position, their head/necks and necks are normally on the pillows; trunks are paralleled to the floor. Therefore, head/neck and trunk angles in the supine position are lower than the prone one. Neck and trunk pain risks are consequently low in this posture.

Flores-Cruz et al. [27] found a similar result that head flexion was found lower in lying down condition than the sitting and standing ones. Likewise, Dennerlein [28] suggested that seating postures are more neutral when back support is sufficient. Therefore, a stool without a back support may produce a greater angle of head flexion compared to an office chair with ample back support. However, the mean angle of the upper arms in the supine position is greater than the prone. This is due to while playing smartphones in supine condition, the participants compulsorily elevate their arms, shoulders, and elbows to make it more convenient and clearer on smartphone screen watching. In the study of Hanphitakphong et al. [22], it was unveiled that spending longer duration with smartphone playing, shoulder and elbow angles are greater. This researcher found that the flexion angle of the left shoulder was significantly greater at 10 minutes (10.70 ± 11.89 degrees; $p < 0.01$) and 20 minutes (12.67 ± 12.60 degrees; $p < 0.001$) compared with baseline values (8.87 ± 10.86 degrees). Elbow flexion showed that as game time increased, the angle increasingly lifted on both sides. The bilateral elbow flexion angle was significantly greater at 10 minutes (Right 101.70 ± 11.44 degrees; $p < 0.001$ and Left 104.46 ± 12.07 degrees; $p < 0.001$) and 20 minutes (Right 102.37 ± 11.87 degrees; $p < 0.001$ and Left 105.86 ± 11.30 degrees; $p < 0.001$) compared with baseline value (Right 94.58 ± 10.30 degrees and Left 98.35 ± 12.75 degrees). The bilateral elbow flexion angle was significantly greater at 20 minutes ($p < 0.001$) compared with this value at 10 minutes [22].

Short-term effects of MSDs on smartphone users using lying postures

According to the findings, it was found that the student participants, who played smartphones on supine posture, have experienced the short-term effects of musculoskeletal pain. In this posture, the lower and upper arms are found to be the most common musculoskeletal pain. Considering the prone position, head/neck, upper arms, and trunk are reported the most affected areas of muscle pain. Additionally, the postures of smartphone users are found to significantly correlate with head/neck, upper arms, and trunk pain ($p < 0.05$). The findings have been consistent with the differences of average angles of head/neck, trunk, and upper arms in prone positions which are higher than the supine ones when playing smartphones. In addition, in prone posture, the musculoskeletal pains have been found greater at head/neck, trunk, and upper arms than the supine condition. These could possibly be explained that using a smartphone in lying supine posture, head/neck and trunk are parallel to the floor with pillow support. Therefore the risk of head/neck and trunk pain is lower than using a smartphone in prone posture. The study of postures of smartphone users with head/neck and shoulder support revealed that the chair support (armrests and back support) reduced head/neck flexion ($p < 0.001$), gravitational moment ($p < 0.001$), and muscle activity ($p < 0.01$) in the neck and shoulder regions significantly compared to no chair support. These results indicate that biomechanical exposures leading to muscular pain in the neck and shoulders during mobile phone use can be diminished with sufficient and effective support of a chair [29]. In a similar way, plying smartphone in the prone position is associated with higher muscle activity in neck extension [19]. In this study, the participants spent an average of 40 minutes per time playing smartphones. Hanphitakphong et al. [22] suggested that a proper duration of smartphone playing for children aged 10 -18 years should not be over 10 minutes. An overuse of smartphones can cause biomechanical effects around the neck area. Relatedly, the upper arm muscles have been highly activated when excessive use is performed. There is a significant difference in upper limb muscular discomfort between two groups of low- and high-users ($P=0.033$) [30].

Comparison of the differences between factors and durations while using smartphones in lying postures

According to the comparison results between various factors and durations of smartphone use in lying postures, the difference of factors and lengths when using smartphones in lying postures is statistically significant ($p < 0.05$). Different factors of

age, smartphone ownership, smartphone usage posture, musculoskeletal symptom have shown different lengths of smartphone usage in lying positions. The student participants aged over 10 years have a longer duration of smartphone playing than those under 10 years. This is congruent with the prospective follow-up study of neck pain in school students aged between 10 to 15 and found that smartphone use was the most frequent activity among 10 years old children. An increase mostly occurred between the ages of 12 and 15. Negative effects caused by muscle pains have affected school achievement, emotional well-being, sleep behavior, and overall health and well-being [31]. It can be explained that in this study, the samples were upper-primary school children aged over 10 years who were in good physical condition and had more concentration than the children aged lower than 10, they therefore tend to spend more time on smartphone playing. Evidence of the study of Saxena et al. proposed that children have a lower pain threshold than adults [32]. According to Wu et al. [15], it was found that the difference in age of participants and game duration may lead to small differences in pain level. Considering at smartphone ownership factor, it was found that the users have different durations of playing if the smartphones belong to them. The children who use their own smartphones tend to play longer than those who do not. The result from the interview indicated that the non-smartphone owners did not carry their smartphones to school. For this group, they can play smartphone only on weekday's after-school time or on the weekends. In contrast with the smartphone owner group, they frequently played with their mobiles during break time or lunch time. In addition, the researchers noticed that there was also a rule for smartphone playtime set by parents of the participants. There is more playtime limitation for non-smartphone owners than the other group. Smartphones can be used for tasks whenever and wherever people need them. As a result, they allow people to evenly switch between multiple tasks on the move [33]. Oulasvirta et al. [34] found that when compared to laptop computer use, the smartphones is significantly shorter in duration, more seamlessly spread throughout the day, and less than twice the total time spent. In a comparison of lying posture and duration of smartphone playing, it was found that playing the phone in different lying positions has different durations of smartphone use. The result showed that a longer duration of smartphone use is frequently found in a prone position than in the supine one. This is opposite to the study conducted on Sleep Apnea patients and found that the participants use prone and supine patterns with a frequency of 0.8% and 55%, respectively [35]. However, the interview result in this present study indicated that the

participants feel more comfortable in prone condition- using their hands and wrists more independently to control smartphones, placing their elbows to the floor, and have more and long concentration on the phones. Whereas in the supine position, there is elbow and shoulder elevation during smartphone use and it can easily lead to muscle fatigue. Evidence from the study also confirmed that the MSDs of lower arms has greater in lying supine than the prone condition.

CONCLUSION

Lying supine is the most common posture used among the children participants when using smartphones. However, using a smartphone in lying down affects the mean angles of the head/neck, trunk, and upper arms. Especially the mean angles of the head/neck, trunk, and upper arms in the prone position are higher than that of the supine one. Moreover, the postures of smartphone users are found to significantly correlate with head/neck, upper arms, and trunk pain. The Musculoskeletal pain of the head/neck, trunk, and upper arms of smartphone users in the supine position is higher than the supine posture. In addition, different factors of age, smartphone ownership, and postures have a significant difference in the duration of smartphone use in a lying position ($p < 0.05$).

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Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Statista. A Device usage increase due to the coronavirus worldwide 2020. Available: <https://www.statista.com/statistics/1106590/device-usage-coronavirus-worldwide-by-generation/#statisticContainer> (Accessed 12 November 2021).
2. Nation Statistical Office. The 2019 Household survey on the use of information and communication technology. Available: http://www.nso.go.th/sites/2014/DocLib13/full_report62.pdf (Accessed 13 November 2021).
3. Ekinci Ö., Çelik T., Savaş N., Toros F.: Association Between Internet Use and Sleep Problems in Adolescents. *Noro Psikiyatr Ars.* 2014;51(2):122-128. doi:10.4274/npa.y6751
4. Twenge JM, Krizan Z, Hisler G.: Decreases in self-reported sleep duration among U.S. adolescents 2009-2015 and association with new media screen time. *Sleep Med.* 2017;39:47-53. doi:10.1016/j.sleep.2017.08.013
5. Elhai JD, Levine JC, Hall BJ.: The relationship between anxiety symptom severity and problematic

- smartphone use: A review of the literature and conceptual frameworks. *J Anxiety Disord.* 2019; 62:45-52. doi:10.1016/j.janxdis.2018.11.005
6. Lee S, Kang H, Shin G.: Head flexion angle while using a smartphone. *Ergonomics.* 2015;58(2):220-226. doi:10.1080/00140139.2014.967311
 7. Namwongsa S, Puntumetakul R, Neubert MS, Boucaut R.: Effect of neck flexion angles on neck muscle activity among smartphone users with and without neck pain. *Ergonomics.* 2019;62(12):1524-1533. doi:10.1080/00140139.2019.1661525
 8. Middleditch A, Oliver J.: *Functional Anatomy of the Spine.* 2nd Edition. Cambridge: Butterworth-Heinemann; 2005.
 9. Falla D, Jull G, Russell T, Vicenzino B, Hodges P.: Effect of neck exercise on sitting posture in patients with chronic neck pain. *Phys Ther.* 2007; 87(4):408-417. doi:10.2522/ptj.20060009
 10. Ashurst JV, Turco DA, Lieb BE.: Tenosynovitis caused by texting: an emerging disease. *J Am Osteopath Assoc.* 2010; 110(5):294-296.
 11. Xie Y, Szeto GP, Dai J, Madeleine P.: A comparison of muscle activity in using touchscreen smartphone among young people with and without chronic neck-shoulder pain. *Ergonomics.* 2016;59(1):61-72. doi:10.1080/00140139.2015.1056237
 12. Ospina-Mateus H, Niño-Prada B, Tilbe-Ayola K, Contreras-Ortiz S, (eds): *Ergonomic and Biomechanical Evaluation of the use of Computers, Tablets and Smart Phones by Children. A Pilot Study.* Singapore: Springer Singapore; 2017.
 13. Gold JE, Driban JB, Yingling VR, Komaroff E.: Characterization of posture and comfort in laptop users in non-desk settings. *Appl Ergon.* 2012;43(2):392-399. doi:10.1016/j.apergo.2011.06.014
 14. Chheda P, Pol T.: Effect of Sustained Use of Smartphone on the Craniovertebral Angle and Hand Dexterity in Young Adults. *IJSR.* 2019;8:1387-90.
 15. Wu G, van der Helm FC, Veeger HE, et al.: ISB recommendation on definitions of joint coordinate systems of various joints for the reporting of human joint motion--Part II: shoulder, elbow, wrist and hand. *J Biomech.* 2005; 38(5):981-992. doi:10.1016/j.jbiomech.2004.05.042
 16. Dickinson CE, Champion K, Foster AF, Newman SJ, O'Rourke AM, Thomas PG.: Questionnaire development: an examination of the Nordic Musculoskeletal questionnaire. *Appl Ergon.* 1992; 23(3):197-201. doi:10.1016/0003-6870(92)90225-k
 17. International Organization for Standardization, ISO 11223: 2001 *Ergonomics. Evaluation of static working postures,* 2001.
 18. Kanchanomai S, Janwantanakul P, Pensri P, Jiamjarasrangsi W.: Risk factors for the onset and persistence of neck pain in undergraduate students: 1-year prospective cohort study. *BMC Public Health.* 2011;11:566. Published 2011 Jul 15. doi:10.1186/1471-2458-11-566
 19. Xie Y, Szeto GP, Dai J, Madeleine P.: A comparison of muscle activity in using touchscreen smartphone among young people with and without chronic neck-shoulder pain. *Ergonomics.* 2016;59(1):61-72. doi:10.1080/00140139.2015.1056237
 20. Lee JH, Hoshino Y, Nakamura K, Kariya Y, Saita K, Ito K.: Trunk muscle weakness as a risk factor for low back pain. A 5-year prospective study. *Spine (Phila Pa 1976).* 1999;24(1):54-57. doi:10.1097/00007632-199901010-00013
 21. Mueller S, Stoll J, Cassel M, Engel T, Mueller J, Mayer F.: Trunk peak torque, muscle activation pattern and sudden loading compensation in adolescent athletes with back pain. *J Back Musculoskelet Rehabil.* 2019;32(3):379-388. doi:10.3233/BMR-181215
 22. Hanphitakphong, P, Thawinchai N, Poomsalood, S.: Effect of prolonged continuous smartphone gaming on upper body postures and fatigue of the neck muscles in school students aged between 10-18 years. *Cogent Engineering,* 2021; 8(1), 1890368. doi: 10.1080/23311916.2021.1890368
 23. Lee S, Lee D, Park J.: Effect of the cervical flexion angle during smart phone use on muscle fatigue of the cervical erector spinae and upper trapezius. *J Phys Ther Sci.* 2015;27(6):1847-1849. doi:10.1589/jpts.27.1847
 24. Straker LM, Coleman J, Skoss R, Maslen BA, Burgess-Limerick R, Pollock CM.: A comparison of posture and muscle activity during tablet computer, desktop computer and paper use by young children. *Ergonomics.* 2008;51(4):540-555. doi:10.1080/00140130701711000
 25. Chimenti PC, Hammert WC.: Ulnar neuropathy at the elbow: an evidence-based algorithm. *Hand Clin.* 2013;29(3):435-442. doi:10.1016/j.hcl.2013.04.013
 26. Keir PJ, Bach JM, Hudes M, Rempel DM.: Guidelines for wrist posture based on carpal tunnel pressure thresholds. *Hum Factors.* 2007;49(1):88-99. doi:10.1518/001872007779598127
 27. Flores-Cruz G, Sims VK, Whitmer DE.: A Study on Head Flexion During Mobile Device Usage: An Examination of Sitting, Standing, and Lying Down Positions. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting.* 2019;63(1):511-515. doi:10.1177/1071181319631047
 28. Dennerlein JT.: The state of ergonomics for mobile computing technology. *Work.* 2015;52(2):269-277. doi:10.3233/WOR-152159
 29. Syamala KR, Ailneni RC, Kim JH, Hwang J.: Armrests and back support reduced biomechanical loading in the neck and upper extremities during mobile phone use. *Appl Ergon.* 2018;73:48-54.
 30. Syamala KR, Ailneni RC, Kim JH, Hwang J.: Armrests and back support reduced biomechanical loading in the neck and upper extremities during mobile phone use. *Appl Ergon.* 2018;73:48-54. doi:10.1016/j.apergo.2018.06.003
 31. Gustafsson ML, Laaksonen C, Aromaa M, Löyttyniemi E, Salanterä S.: The prevalence of neck-shoulder pain, back pain and psychological symptoms in association with daytime sleepiness - a prospective follow-up study of school children aged 10 to 15. *Scand J Pain.* 2018;18(3):389-397. doi:10.1515/sjpain-2017-0166

32. Saxena I, Kumar M, Barath AS, Verma A, Garg S, Kumar M.: Effect of Age on Response to Experimental Pain in Normal Indian Males. *J Clin Diagn Res.* 2015;9(9):CC05-CC8. doi:10.7860/JCDR/2015/15385.6516
33. Rogers Y, Connelly K, Hazlewood W, Tedesco L.: Enhance learning: A study of how mobile devices can facilitate sensemaking. *Pers Ubiquit Comput.* 2010;14:111–124. doi: 10.1007/s00779-009-250-7
34. Oulasvirta A, Rattenbury T, Ma L et al. Habits make smartphone use more pervasive. *Pers Ubiquit Comput* 2012;16:105–114 . doi.10.1007/s00779-011-0412-2
35. Ferrer-Lluis I, Castillo-Escario Y, Montserrat JM, Jané R. Enhanced Monitoring of Sleep Position in Sleep Apnea Patients: Smartphone Triaxial Accelerometry Compared with Video-Validated Position from Polysomnography. *Sensors.* 2021; 21(11):3689. doi:10.3390/s21113689

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THE THEORY OF REASONED ACTION IN DESCRIBING TONGUE CLEANING ADHERENCE AMONG COLLEGE GOING STUDENTS OF INDIA: A MODEL GUIDED STUDY

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ABSTRACT

Background. Just mere brushing of teeth is not enough for maintaining good oral health. Regular cleaning of tongue is equally important for maintaining good oral hygiene and to escape social embarrassment and personal discomfort, which could arise as a result of halitosis.

Objective. To test the variables of Theory of Reasoned Action to explain the behavior of tongue cleaning among college going students of Udaipur city, Rajasthan, India.

Material and methods. A descriptive cross-sectional survey was conducted amongst 756 college going students of Udaipur city, India using an online self-administered structured questionnaire which was designed based on our study objectives. Logistic regression analysis and structural equation modelling (SEM) were employed for statistical analysis. Confidence level and level of significance were set at 95% and 5% respectively.

Results. Logistic regression analysis showed that with one unit increase in subjective norm, the tongue cleaning behavior odds increased significantly by 1.124. Also, the tongue cleaning behavior odds was 1.77 times significantly greater among those brushing their teeth twice a day than those brushing once a day. Structural Equation modelling also evidenced the significant direct effect of subjective norm on tongue cleaning behavior ($\beta = 0.2$, $p \leq 0.05$).

Conclusion. Our results highlighted the importance of subjective norms in espousing tongue cleaning preventive behaviour habit. It is thus recommended to highlight the role of significant others in changing tongue cleaning behaviour.

Key words: *theory of reasoned action, preventive behavior, tongue coating, tongue cleaning, oral hygiene*

INTRODUCTION

As claimed by the World Health Organization (WHO), health of an individual is directly linked to his/her oral health [1]. Furthermore, oral health is reasoned to be an important factor that settles and resolves different facets of quality of life [1, 2]. Our mouth houses not a single group of microorganisms but a large community that interacts with each other in a complex manner. It is not surprising to know that the habitat of these microbial metabolic activities is the dental plaque [3].

Maintaining proper oral hygiene with efficient plaque removal methods is of utmost importance. The dental industry is flooded with oral care products which serve various purposes like mouth cleansing, maintain a fresh odorless breath and maintain efficient oral hygiene [4]. Regular cleaning of tongue is equally important for maintaining good oral hygiene and to escape social embarrassment and personal discomfort, which could arise as a result of halitosis [5]. Tongue coating is considered as a major etiological factor for oral malodor. For approximately 90% of the cases, it is seen that halitosis can be classified as intra oral halitosis [6]. In addition to this, the tongue coating

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incorporates a wide range of bacteria, secretions from post nasal area, gingiva, saliva and deceased epithelial cells [7]. The dorsum of the tongue should be regularly cleaned as a part of oral hygiene measure to have a considerable effect on the levels of plaque as compared to toothbrushing done alone [8]. As dentists, educating patients is contemplated to be a trademark of our noble profession.

The development of various theories and behavioral models have been a major breakthrough in the field of dental education. In accordance with this theory, the best predictor of subsequent behavior is intention and the intentions are further based on attitude towards performing the behavior and perceived social norms about performing the behavior [9]. In this theory, the attention is focused on the fact that attitudes and intentions together can bring about a change in the behavior. There are two cognitive models that work together to develop a healthy behavior – assumption what the other people contemplate and the desire and impulse to conform with them [10]. Since the role of other people is also included in this theory, it makes it all the way more interesting [11].

This study is intended with the purpose to test the variables of Theory of Reasoned Action to explain the current behavior of tongue cleaning amidst college going students of Udaipur city, Rajasthan, India.

MATERIALS AND METHODS

Study design, study population and study area

An online descriptive survey was conducted amongst 756 college going students of Udaipur city, Rajasthan, India.

Ethical approval

The study was approved by the institutional ethical committee and was acknowledged with the ethical clearance (PDCH/21/EC-287). Deans of the institutes selected for the study were contacted for necessary permissions and the official permission letters were obtained.

Informed consent

Study subjects were made aware about the goals and details of the present research and informed consent (online) was obtained prior to the study.

Inclusion criteria

Subjects who belonged to the age group of 18-30 years.

Exclusion criteria

Study subjects who were pursuing medical, paramedical and dentistry courses. Those who were

reluctant to participate in the study. Those who consumed tobacco in any form (smoked/smokeless).

Questionnaire

An online (google form) self-administered structured and organized questionnaire was established on the basis of our study manifesto. The questionnaire comprised of 3 sections – the initial section gathered the basic demographic specifics counting for name, age, gender, religion, monthly income, level of education and geographic location. Socioeconomic status was classified according to Prasad's Classification of socioeconomic status scale. A close ended question to enquire about tobacco consumption in any form (smoked/smokeless) was also added in the first section of questionnaire.

The next segment of the questionnaire comprised of 9 model guided items (Theory of Reasoned Action) with responses on *Likert's* scale of agreement. It included questions regarding tongue cleaning behavior (2Q), intention (1Q), attitude towards tongue cleaning (3Q) and subjective norms (3Q). The third section consisted of two close ended questions on oral health behavior to gather information on the regularity of tooth brushing and tongue cleaning habits.

Pre testing survey

A pretesting survey was conducted amongst a group of 12 students. These participants were then contacted to obtain their suggestions on the general acceptance pertaining to the number of questions, understandability and any other problem faced while submitting the responses. A high Cronbach's coefficient of 0.78 made the questionnaire acceptable in terms of internal consistency.

Questionnaire was validated based on the judgements of five senior faculty members. Based on their scores, content validity ratio was found to be 0.91. Furthermore, during the assessment of face validity, 95% of the study subjects assessed the survey form as simple and clear.

Sample size calculation

Using G power software, the findings of the pilot study, 80% power of study and 95% confidence level, the estimated sample size came out to be 756.

Sampling methodology

Before the instigation of the study, a list of the university institutes of Udaipur, Rajasthan was prepared. Amongst them, one university was randomly picked up. All the constituent colleges of the university formed different stratas (homogenous groups) and the subjects were selected using stratified random sampling. The number of participants selected in each stratum was in proportion to the students

enrolled in each college to reach the desired sample size of 756 (Probability Proportional sampling). The proportion of students chosen varied in all the colleges accordingly.

Methodology

After selecting the desired study subjects, their contact numbers were gathered. Sensitization of the study subjects regarding the research study was done via WhatsApp. Timely reminders were given to the study subjects to fill up the google form and they were advised to fill it up very carefully. The response rate was 100%.

Statistical analysis

Analysis was done using SPSS version 24 (IBM SPSS statistic Inc, Chicago, IL) windows software program. Descriptive statistics were calculated to determine the frequency of responses regarding tongue cleaning behavior among the study subjects. Binary logistic regression analysis was done multivariate analysis. The hypothesized model was tested using structural equation modelling. Model was verified using IBM SPSS AMOS 16.0. As per the standard, model was found to be good which was supported by the values of RMSEA (root mean square error of approximation) CFI (comparative fit index) and AIC (Akaike's information criteria) along with a non-significant *Chi* square [12]. The model with subjective norm, attitude, intention and preventive behavior was an acceptable fit to the data.

RESULTS

In a total population of 756 subjects, majority of the respondents were males (n= 353, 59.0%) and belonged

to 21-25 years of age group (n = 459, 76.5%). Around 55.7% (n = 334) and 51.0% (n = 306) of the study subjects belonged to urban locations and were post-graduates respectively. Nearly 53.0% (n = 318) of the study subjects belonged to upper class socio-economic status, followed by 21.8% (n = 131) of the subjects belonging to upper middle class socioeconomic status. Only 3.3% (n =20) of the study subjects belonged to lower class socio economic status (Table 1).

Table 1. Distribution of study population according to demographic variables

Variables	Number (n)	Percentage (%)
Age group (years)		
18-20	62	10.3
21-25	459	76.5
>25	79	13.2
Gender		
Male	353	59.0
Female	247	41.0
Place of residence		
Rural	266	44.3
Urban	334	55.7
Per capita income		
Upper class	318	53.0
Upper middle class	131	21.8
Middle class	85	14.2
Lower middle class	46	7.7
Lower class	20	3.3
Educational qualification		
Under- graduation	296	49.0
Post-graduation	306	51.0
Total	600	100

Table 2. Frequency of responses to questions concerning Theory of Reasoned Action among study subjects

Questions	Strongly agree n (%)	Agree n (%)	Disagree n (%)	Strongly disagree n (%)
<i>INTENTION</i>				
I intend to clean my tongue once a day/ more	220 (36.7)	288 (48.0)	65 (10.8)	27 (4.5)
<i>ATTITUDE</i>				
By cleaning tongue, one can prevent halitosis	283 (47.2)	244 (40.7)	36 (6.0)	37 (6.2)
By cleaning tongue, one can maintain good oral hygiene	228 (47.2)	246 (41.0)	84 (14.0)	42 (7.0)
Regular tongue cleaning means healthier oral cavity, which can make you look & feel better about yourself	100 (16.7)	298 (49.7)	178 (29.7)	24 (4.0)
<i>SUBJECTIVE NORM</i>				
Most people who are important to me, think that I should clean my tongue	300 (50)	100 (16.7)	150 (25)	50 (8.3)
By cleaning tongue, I can set an example for others by looking and feeling better about myself	257 (42.8)	291 (48.5)	25 (4.2)	27 (4.5)
By cleaning tongue, I can have a nice smile and healthy oral cavity and I can impress people around me	400 (66.6)	75 (12.5)	100 (16.7)	25 (4.1)

The frequency of responses to answers concerning intention, attitude and subjective norms regarding tongue cleaning behavior were calculated. Around 48.0 % (n = 288) of the study subjects agreed that they intend to clean their tongue once a day or more. It was observed that, 47.2% (n = 283) of the study

subjects strongly agreed that by cleaning tongue, one can prevent halitosis and maintain good oral hygiene. More than half i.e 66.6% (n = 400) of the study subjects strongly agreed that by cleaning tongue, one can have a nice smile and healthy oral cavity and can impress people around them (Table 2).

Table 3. Binary Logistic Regression analysis with tongue cleaning behavior as dependent variable

Variables	Tongue Cleaning Behavior Odds ratio (95% CI)	P value
Attitude	0.963 (0.846-1.096)	0.56
Subjective Norm	1.124 (0.986-1.280)	0.05*
Intention	1.064 (0.825-1.371)	0.63
Age (years)		
18-20	0.875 (0.365-2.096)	0.764
21-25	0.808 (0.420-1.554)	0.523
>25 ^a	-	-
Tooth brushing frequency		
Twice a day	1.77 (0.516-1.173)	0.001*
Once a day ^a	-	-
Per capita income		
Upper class	0.684 (0.336-1.393)	0.296
Upper middle class	1.440 (0.831-2.495)	0.194
Middle class	0.598 (0.324-1.046)	0.235
Lower middle class	3.06 (0.653-1.968)	0.103
Lower class ^a	-	-
Gender		
Female	1.081 (0.711-1.042)	0.05*
Male ^a	-	-
Education		
Under-graduation	3.968 (0.546-1.304)	0.000*
Post-graduation ^a	-	-

Test applied - Binary logistic regression; *p<0.05 statistically significant

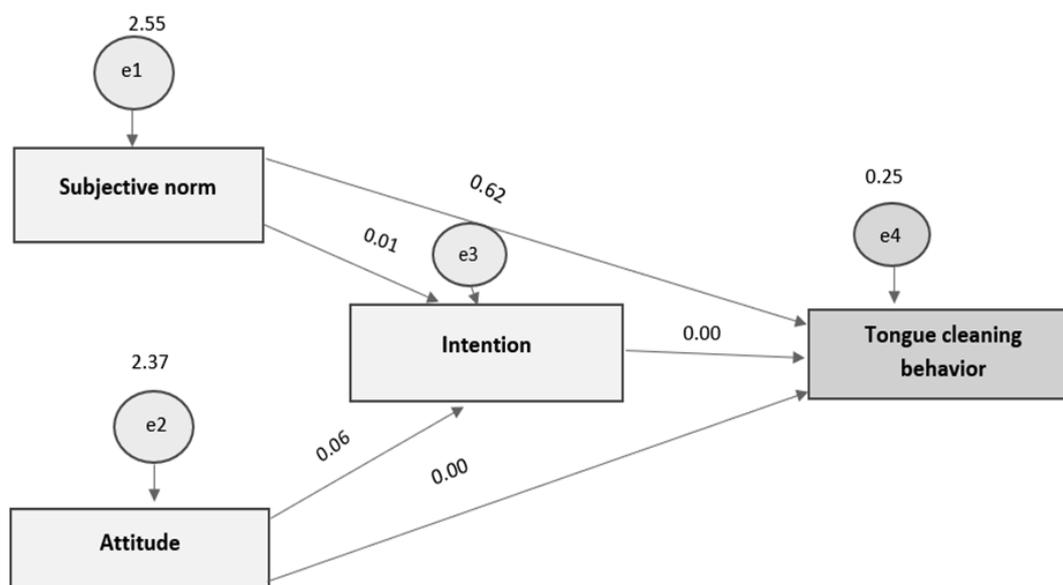


Figure 1. Structural equation model analysis for the determinants of tongue cleaning behavior using Theory of Reasoned Action

Binary logistic regression analysis with tongue cleaning behavior as a dependent variable was analyzed. It was observed that significant greater odds of 3.968 and 1.081 was seen among the undergraduates and female study subjects than postgraduates and male subjects respectively, concerning the tongue cleaning behavior. With one unit increase in subjective norm, the tongue cleaning behavior odds increased significantly by 1.124. Also, the tongue cleaning behavior odds was 1.77 times significantly greater among those brushing their teeth twice a day than those brushing once a day (Table 3).

Figure 1 depicts that the direct effect of subjective norm on tongue cleaning behavior was significant ($\beta = 0.2, p \leq 0.05$). The indirect direct effects of attitude and intention on tongue cleaning behavior were non – significant ($p \geq 0.05$). Specific indirect effects were estimated by multiplying the direct effects of the variables involved in total pathway.

DISCUSSION

People of all ages have benefitted immensely from daily and routine oral health behaviors. These everyday practices contribute to improved oral health status. Rendering preventive dental care has shown to explain the reason behind notable gains in the oral health status and quality of life [13]. To boost and escalate the awareness pertaining to healthy actions, health behavior models have been refined time and again and inculcated in related investigations and analysis. It should be noted that an adjustment and alteration is required in behavior so as to cultivate health and bypass illness. A deficiency in adhering to acceptable healthy conduct can be clearly witnessed in every sections of the society, irrespective of literacy and socioeconomic status.

College going population also does not exhibit any distinctive features when compared to their synonymous groups. This population is no more in their cocoons and in the immediate presence of their parents to constantly emphasize them to brush their teeth or clean their tongue. The simple oral hygiene practices like brushing and flossing of teeth and cleaning of teeth can completely escape from their memories and they may even continue to do this for several days. Students as a community cannot be neglected because they offer a critical and crucial role bringing about revolution in the field of behavioral change. Consequently, it becomes very important to construct an awareness in their minds in view of the application of oral hygiene practices in day-to-day life.

The various psychological assumptions and concepts that are seeded on oral health education has immensely helped in advertising a change in knowledge, attitudes, perceptions, all of this leading

towards the wider goal of changing behavior. Taking this into account, the current research was directed to determine the efficacy of the variables of the Theory of Reasoned Action (attitude, subjective norm and perceived behavioral control) amongst the college going students.

Till date, nowhere in the literature has tongue cleaning behavior been scrutinized in relation to *Ajzen* and *Fishben's* model. Studies on the past have focused on oral health behavior and oral self-care habits. As per the Theory of Reasoned Action, analytical decisions are made by individuals as per their awareness, morals and mindset. Hence, an individual's aim to accomplish a behavior is the utmost important interpreter of executing that behavior. Behavioral beliefs and normative beliefs are two kinds of beliefs that shape intentions. Intent to perform an action must be constant and consistent to bring about the change in behavior [14]. When faced with an unforeseen hindrance, there may be a divergence from the path of healthy behaviors. Social norms and community expectations are powerful predictors of healthy action, as per the Theory of Reasoned Action [15].

Study conducted by *Pedrazzi et al* [16] has projected that around 85% of all halitosis have their source in the mouth, of these 50% are triggered by tongue residues. Thus, tongue cleaning advances to be on the top position for halitosis management and promoting good overall health when complemented with toothbrushing and flossing.

The results of our study confirmed that subjective norm concerning tongue cleaning was related significantly to the tongue cleaning behavior. Studies conducted by *Kawakami et al* [17] has shown that social surroundings of an individual, which includes friends, family and colleagues, are significant in patient care. The significant effect of subjective norms on preventive behavior was also justified by *Bratt* [18]. He stated that friends, family and colleagues, could increase a person's awareness to the consequences of his/her actions and encourage the individual to take responsibility for his/her action. He stated that social norm revealed direct link to behavior.

However, our results are in dissimilarity with the findings of *Dumitrescu et al* [13], which revealed that attitude was of paramount importance in predicting the intention. This difference in the study results could be because of the fact that both affective and instrumental attitudes were included as separate constructs in their study and parental attitudes towards child's oral health were studied as well. Subjective norms did not significantly contribute to the prediction of behavior was supported by the findings of *Rhodes et al* [19], *Saunders et al* [20] and *Fen & Sabaruddin* [21]. These differences could be because of the fact that the

Theory of Reasoned Action may perform differently in different socio-cultural contexts.

In our study, the subjective norm seemed to be important for tongue cleaning which advocates the inclusion of significant others in oral health promotion programmes.

The results of our study also suggested that women had better oral health orientation than males, as they had greater odds of tongue cleaning compared to the males. This result was supported by the studies conducted by *Syrjala et al* [22], *Knecht et al* [23], *Davidson et al* [24] and *Sakki et al* [25]. Female's adherence to a healthier behavior may be an implication of several contextual psychological aspects.

Higher odds of 3.968 was observed amongst the undergraduates as compared to post graduate students, which suggests dearth of hours which they can actually devote in maintaining a healthy oral cavity. Also, as anticipated, tongue cleaning behavior odds was 1.77 times greater among those brushing their teeth two times daily than once a day. Our results concluded, that socio economic status did not significantly affect the tongue cleaning behavior. Although demographic factors strongly influence oral health yet they play a negligible role because a clinician/ practitioner cannot directly modify demographic factors [26]. In addition to this, tongue cleaning as a practice for maintaining good oral hygiene does not cost an arm and a leg and is a budget friendly practice, requiring no special tools.

The use of structural equation modelling analysis, permitted in identification of factors associated positively with tongue cleaning behaviour, thereby suggesting improvements in further educational models and rendering our study statistically more competent. The current results might pave a way for dental professionals to educate masses and bring about a change in person's oral health promoting behaviour. At last, health professions should enquire regarding peer pressure evidenced by the subjects that might eventually predict actions. Involvement of significant others like partners, colleagues or other people in the surroundings in oral health educational might be further beneficial. When employed, these strategies, in addition to traditional patient education, are likely to result in more robust interventional efforts.

CONCLUSION

Present research suggested the importance of subjective norms for tongue cleaning preventive behaviour. In the companionship of significant others, rendering oral health education to college going students would be of help. Keeping in mind the future prospective, it could be of use to objectify the role of social surroundings which might reinforce the

subjective norms and attitudes regarding the tongue cleaning behaviour amongst college going students.

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REFERENCES

1. *Shahnazi H, Hosseintalaei M, Ghashghaei FE, Charkazi A, Yahyavi Y, Sharifirad G.*: Effect of educational intervention on perceived susceptibility self-efficacy and DMFT of pregnant women. *Iranian Red Crescent Medical Journal.* 2016;18(5):e24960, doi:10.5812/ircmj.24960
2. *Haerian Ardakani A, Morowatisharifabad MA, Rezapour Y, Pourghayumi Ardakani A.*: Investigation of the relationship of oral health literacy and oral hygiene self-efficacy with self-reported oral and dental health in students. *Tolooebehdasht.* 2015;13(5):125-40.
3. *Ferrer MD, Pérez S, Lopez AL, Sanz JL, Melo M, Llena C, Mira A.*: Evaluation of Clinical, Biochemical and Microbiological Markers Related to Dental Caries. *Int J Environ Res Public Health* 2021;18(11):6049, doi: 10.3390/ijerph18116049.
4. *Alshahrani S, Alshuaibi A, Alkhalidi M, Koppolu P.*: Perception and Knowledge of Patients from Different Regions in the Kingdom of Saudi Arabia towards Oral Hygiene and Oral Hygiene Aids. In *Healthcare* 2021;9(5):592, doi: 10.3390/healthcare9050592.
5. *Seemann R, Conceicao MD, Filippi A, Greenman J, Lenton P, Nachnani S, Quirynen M, Roldán S, Schulze H, Sterer N, Tangerman A.*: Halitosis management by the general dental practitioner—results of an international consensus workshop. *J Breath Res* 2014;8(1):0171.
6. *Seerangaiyan K, Jüch F, Winkel EG.*: Tongue coating: Its characteristics and role in intra-oral halitosis and general health—A review. *J Breath Res* 2018;12(3):034001.
7. *Yaegaki K, Sanada K.*: Biochemical and clinical factors influencing oral malodor in periodontal patients. *J Periodontol.* 1992;63(9):783-9.
8. *Dumitrescu AL, Dogaru BC, Duta C, Manolescu BN.*: Testing five social-cognitive models to explain predictors of personal oral health behaviours and intention to improve them. *Oral Health Prev Dent.* 2014;12:345-55.
9. *Tedesco LA, Keffer MA, Davis EL, Christersson LA.*: Effect of a social cognitive intervention on oral health

- status, behavior reports, and cognitions. *J Periodontol* 1992;63:567-75.
10. *Anderson CN, Noar SM, Rogers BD.*: The persuasive power of oral health promotion messages: a theory of planned behavior approach to dental checkups among young adults. *Health Commun* 2013;28(3):304-313, doi: 10.1080/10410236.2012.684275.
 11. *Khairnar M, Kumar P, Kusumakar A.*: Updated BG prasad socioeconomic status classification for the year 2021. *J Indian Assoc Public Health Dent* 2021;19:154-158.
 12. *Byrne B.*: Structural equation modelling with AMOS. Basic concepts, applications and programming. London: Lawrence Erlbaum Associates Publishers, 2001
 13. *Dumitrescu AL, Wagle M, Dogaru BC, Manolescu B.*: Modeling the theory of planned behavior for intention to improve oral health behaviors: the impact of attitudes, knowledge, and current behavior. *J Oral Sci*. 2011;53:369-77, doi: 10.2334/josnugd.53.369.
 14. *Tedesco LA, Keffer MA, Davis EL, Christersson LA.*: Effect of a social cognitive intervention on oral health status, behavior reports, and cognitions. *J Periodontol* 1992;63:567-575.
 15. *Ajzen I.*: The theory of planned behavior. *Organ Behav Hum Decis Process* 1991;50:179-211.
 16. *Pedrazzi V, Sato S, de Mattos MD, Lara EH, Panzeri H.*: Tongue-cleaning methods: a comparative clinical trial employing a toothbrush and a tongue scraper. *J Periodontol* 2004;75(7):1009-12.
 17. *Kawakami, N., Akachi, K., Shimizu, H., Haratani, T., Kobayashi, F., Ishizaki, M., Hayashi, T., Fujita, O., Aizawa, Y., Miyazaki, S., Hiro, H., Hashimoto, S. & Araki, S.*: Job strain, social support in the workplace, and haemoglobin A1c in Japanese men. *Occup Environ Med* 2000;57:805-809.
 18. *Bratt C.*: The impact of norms and assumed consequences on recycling behavior. *Environment and Behavior*. 1999;31(5):630-56, doi:10.1177/00139169921972272.
 19. *Rhodes RE & Jones LW Courneya KS.*: Extending the theory of planned behavior in the exercise domain: a comparison of social support and subjective norm. *Res Q Exerc Sport* 2002;73: 193-199.
 20. *Saunders RP, Motl RW, Dowda M, Dishman RK & Pate RR.*: Comparison of social variables for understanding physical activity in adolescent girls. *Am J Health Behav*, 2004;28:426-436.
 21. *Fen YS, Sabaruddin NA.*: An extended model of theory of planned behaviour in predicting exercise intention. *Int Business Res* 2008;33:108-122. doi:10.5539/ibr.v1n4p108
 22. *Syrjälä AMH, Niskanen MC, Knuuttila MLE.*: The theory of reasoned action in describing tooth brushing, dental caries and diabetes adherence among diabetic patients. *J Clin Periodontol* 2002;29:427-432, doi: 10.1034/j.1600-051x.2002.290507.x.
 23. *Knecht, M. C., Syrjälä, A.-M. H. & Knuuttila, M. L. E.*: Attributions to dental and diabetes health outcomes. *J Clin Periodontol* 2000;27:205-211.
 24. *Davidson, P. L., Rams, T. E., Andersen, R. M.*: Socio-behavioral determinants of oral hygiene practices among USA ethnic and age groups. *Adv Dent Res* 1997;11(2):245-253. doi: 10.1177/08959374970110020701.
 25. *Sakki, T. K., Knuuttila, M. L. & Anttila, S. S.*: Lifestyle, gender and occupational status as determinants of dental health behavior. *J Clin Periodontol* 1998;25(7):566-70. doi: 10.1111/j.1600-051x.1998.tb02489.x.
 26. *Brein DJ, Fleenor Jr TJ, Kim SW, Krupat E.*: Using the theory of planned behavior to identify predictors of oral hygiene: A collection of unique behaviors. *J Periodontol* 2016;87(3):312-9.

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