

ROLE OF FRUIT AND VEGETABLES FOR THE MENTAL HEALTH OF CHILDREN: A SYSTEMATIC REVIEW¹

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ABSTRACT

Background. About 10-20% of children and adolescents worldwide experience a mental health problems, while among the factors which may be preventive, there is a diet, especially fruit and vegetables intake.

Objective. The aim of the study was to conduct a systematic review of the observational studies analyzing the association between the fruit and vegetables intake and the mental health in pre-schoolers and school-aged children.

Material and methods. The systematic review was conducted based on PubMed and Web of Science databases, while the human studies, published in English until June 2019, conducted in populations of pre-schoolers and/ or school-aged children, verifying the influence of fruit and/ or vegetables and products (e.g. juices) intake on a various aspects of mental health were included.

Results. The number of 12 studies were included, while a wide area of aspects of mental health was taken into account, including general well-being, emotions, stress, behavioral difficulties and problems, as well as depressive symptoms, or depressive symptoms combined with anxiety.

Conclusions. In majority of studies included to the systematic review of the observational studies analyzing the association between the fruit and vegetables intake and mental health in pre-schoolers and school-aged children, the supposed positive influence was confirmed. However, it must be indicated that it was studied only in a few research and the issue must be analyzed in other populations. At the same time, in a number of studies, not fruit and vegetables intake alone was stated to be beneficial, but rather a more general dietary pattern, including also other elements of healthy diet and healthy lifestyle.

Key words: *fruit, vegetables, juices, mental health, child, diet*

STRESZCZENIE

Wprowadzenie. Zaburzenia psychiczne są obecnie coraz powszechniejszym problemem zdrowotnym, dotyczącym około 10-20% dzieci i młodzieży, podczas gdy wśród czynników mających znaczenie w profilaktyce wskazuje się prawidłową dietę, w tym szczególnie spożycie warzyw i owoców.

Cel badań. Celem badań było przeprowadzenie przeglądu systematycznego badań obserwacyjnych dotyczących zależności między spożyciem warzyw i owoców a zdrowiem psychicznym u dzieci w wieku przedszkolnym i szkolnym.

Material i metody. Przegląd systematyczny przeprowadzono w oparciu o bazy PubMed i Web of Science i włączono badania z udziałem ludzi, opublikowane w języku angielskim do czerwca 2019 włącznie, realizowane w populacjach dzieci w wieku przedszkolnym i/ lub szkolnym, które weryfikowały wpływ spożycia warzyw i/ lub owoców oraz ich przetworów (w tym soków) na różne aspekty zdrowia psychicznego.

Wyniki. Włączono 12 badań, obejmujących szeroki zakres czynników związanych ze zdrowiem psychicznym, takich jak generalny dobrostan, emocje, stres, zaburzenia i problemy związane z zachowaniem, jak również objawy depresyjne, lub objawy depresyjne w połączeniu z niepokojem.

Wnioski. W większości badań włączonych do systematycznego przeglądu badań obserwacyjnych oceniających zależność między spożyciem warzyw i owoców a zdrowiem psychicznym u dzieci w wieku przedszkolnym i szkolnym, spodziewana zależność została potwierdzona. Jednakże, należy wskazać, że była ona do tej pory analizowana w niewielu badaniach i należałoby problem ten oceniać także w innych populacjach. Równocześnie, w wielu badaniach, to nie samo spożycie warzyw i owoców było określone jako korzystne, ale raczej obserwowano wpływ generalnych wzorców żywieniowych, obejmujących także inne elementy diety i prozdrowotnego stylu życia.

Słowa kluczowe: *owoce, warzywa, soki, zdrowie psychiczne, dzieci, dieta*

1 The study was financed by the Certified Product 'CP' Quality System (CEN.DRR.WFP.705.350.2018.MR.3) within the National Polish Promotion Fund for Fruits and Vegetables Consumption.

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INTRODUCTION

The World Health Organization (WHO) emphasizes that about 10-20% of children and adolescents worldwide experience a mental health problems, being a leading cause of disabilities in case of young people [26]. Taking it into account, the issues associated with the mental health of children are currently becoming a serious public health issue, being integrated into general medical and primary care, as both mental health promotion and early interventions are indicated among global priorities [27]. Problems associated with mental health of children are experienced in a school settings [23] and in families [22], but the major issue is how to provide an adequate help for children and support them in their situation [25].

A systematic review of primary care practitioners' perceptions by *O'Brien* et al. [18] emphasized the role of significant barriers in primary care for mental health problems, including a lack of providers and resources, extensive waiting lists, and financial restrictions, that were identified as main obstacles for managing the problem. Taking them into account, the prevention is becoming even more vital, as preventive programs may be effective to assure not only proper mental health for the period of childhood, but also adolescence and adulthood [24].

Among the factors which are associated with a mental health of children, there is a diet, being suggested as associated with the depression risk [13] and other mental health problems [19]. Especially the systematic review by *O'Neil* et al. [20] highlight the potential importance of the relationship between dietary patterns, or diet quality and mental health in childhood. However, there is a need to indicate a specific recommendations associated with mental health problems prevention, so it is necessary to verify the influence of a specific dietary behaviors on a general mental health, while among suggested food products and nutrients there are: fruit and vegetables, whole grains, fish, lean meat, olive oil, folate, B vitamins, magnesium, selenium, zinc, Monounsaturated Fatty Acids (MUFA), Polyunsaturated Fatty Acids (PUFA), polyphenols and fiber [12]. Especially for fruit and vegetables, there are some proofs, as for young ones a low fruit and vegetables intake is a longitudinal correlate of poor mental health [10] and young ones with depression commonly do not follow the recommendations of fruit and vegetables intake [9].

However, especially for school children obtaining the recommended intake of fruit and vegetables may be straitened, as their common reluctance or avoidance of unknown food products causes that they often limit the fruit and vegetables intake [7,8]. It corresponds the inadequate fruit and vegetables intake that is commonly observed in various populations of children, including Polish one [6,11]. Taking it into account, the aim of the

presented study was to conduct a systematic review of the observational studies analyzing the association between the fruit and vegetables intake and the mental health in pre-schoolers and school-aged children.

MATERIAL AND METHODS

The systematic review was conducted based on PubMed and Web of Science databases, while the basic search strategy was to include human studies, conducted in populations of pre-schoolers and/ or school-aged children, verifying the influence of fruit and/ or vegetables intake (both as a separate nutritional factor and within the broader characteristics of diet). Only peer-reviewed studies were included, which were published in English until June 2019, while both indicated databases were searched and the additional manual search of the references of included studies was applied.

For the assessment of fruit and vegetables intake, both studies of the fresh unprocessed products were taken into account, and the studies which included the intake of juices, based on the proven role of juices in obtaining a recommended 5-a-day recommendation for fruit and vegetables intake [2]. However, only habitual intake was taken into account and the studies of a short-term dietary interventions were excluded.

For the assessment of mental health, all the aspects were allowed, both in healthy populations and populations with any chronic or acute diseases, while excluding only potential groups with intellectual disabilities, dementia, Attention Deficit Hyperactivity Disorder (ADHD) or eating disorders. The applied search strategy included the criteria for fruit and/ or vegetables intake and mental health, while afterwards the extracted studies were searched once again to include only those conducted for a groups of pre-schoolers and school-aged children. Detailed search strategy is presented in the Table 1 and the search procedure is presented in the Figure 1. The studies were searched independently by 2 researchers based on the titles and afterwards verified by them based on the abstracts, as well as based on the extracted full texts. Any disagreement between researchers was discussed and the final decision was made after consultation with the third researcher. If needed, the authors of the study were asked for the full text of their manuscript.

While the studies were included to the systematic review, the following data were extracted: author, country/location, study group, number of participants, gender proportions, age, method of assessment of fruit and vegetable intake, other fruit and vegetable products included, method of outcome assessment, psychological measure, observations, and conclusions. The results were organized in tables and the narrative review was prepared based on the gathered information.

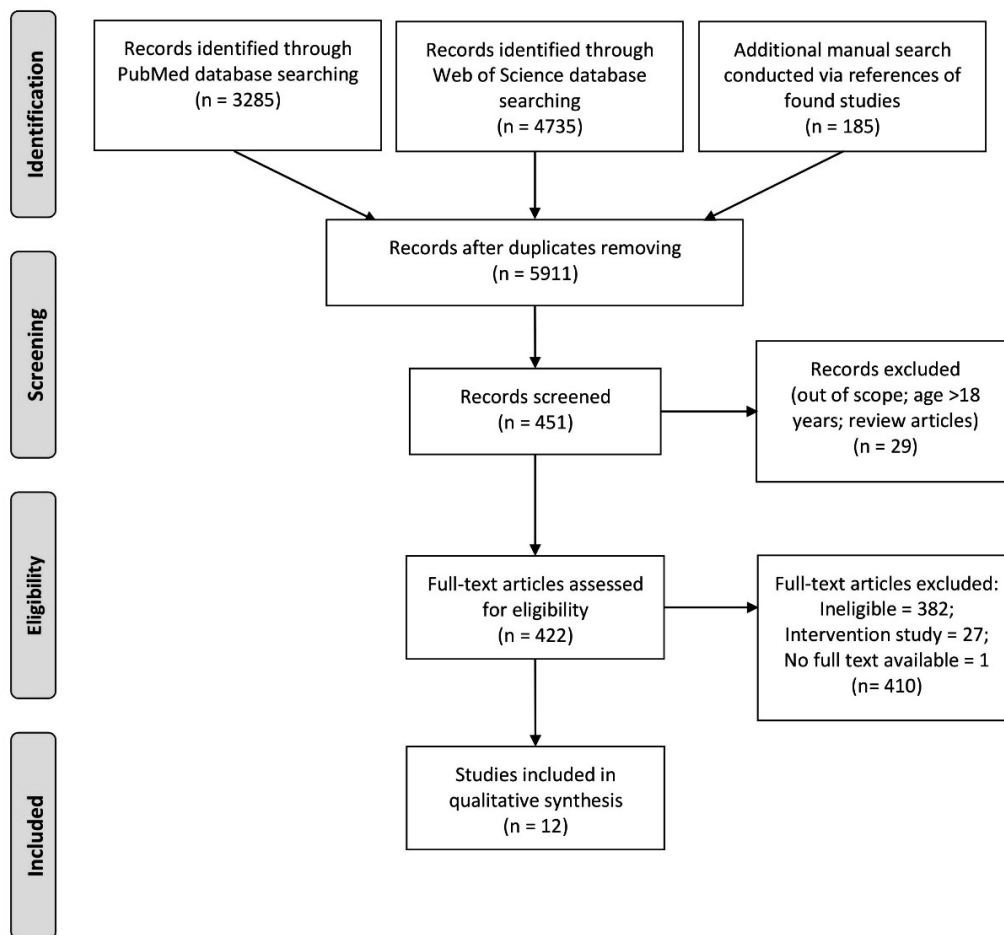


Figure 1. Flow chart of inclusion studies verifying the influence of fruit and vegetables intake on the mental health in children

Table 1. The search strategy detailed for PubMed and Web of Science databases to verify the influence of fruit and vegetables intake on the mental health in children

Database	The applied full electronic search strategy
PubMed	((fruit[Title/Abstract] OR fruits[Title/Abstract] OR vegetable[Title/Abstract] OR vegetables[Title/Abstract] OR juice[Title/Abstract] OR juices[Title/Abstract])) AND (mental health[Title/Abstract] OR mental disorder[Title/Abstract] OR mental disorders[Title/Abstract] OR psychological distress[Title/Abstract] OR mood disorders[Title/Abstract] OR depression[Title/Abstract] OR anxiety[Title/Abstract] OR suicide[Title/Abstract] OR suicidal[Title/Abstract] OR well-being[Title/Abstract] OR wellbeing[Title/Abstract] OR quality of life[Title/Abstract] OR self-esteem[Title/Abstract] OR self esteem[Title/Abstract] OR self-efficacy[Title/Abstract] OR self efficacy[Title/Abstract] OR resilience[Title/Abstract] OR empowerment[Title/Abstract] OR life skills[Title/Abstract] OR social participation[Title/Abstract] OR mental capital[Title/Abstract] OR emotional[Title/Abstract] OR psychosocial[Title/Abstract] OR psychology[Title/Abstract] OR psychiatry[Title/Abstract])) NOT (animal NOT (animal AND human)[MeSH Terms])
Web of Science	(TS=(fruit OR fruits OR vegetable OR vegetables OR juice OR juices) AND TS=(“mental health” OR “mental disorder” OR “mental disorders” OR “psychological distress” OR “mood disorder” OR depression OR anxiety OR suicide OR suicidal OR well-being OR wellbeing OR “quality of life” OR self-esteem OR “self esteem” OR self-efficacy OR “self efficacy” OR resilience OR empowerment OR “life skills” OR “social participation” OR “mental capital” OR emotional OR psychosocial OR psychology OR psychiatry) NOT TS=(animal NOT (animal AND human)))

RESULTS

The number of 12 studies were included to the systematic review based on the described inclusion

procedure. The characteristics of the studied group for the included studies verifying the influence of fruit and vegetables intake on the mental health in children is presented in Table 2.

Table 2. The characteristics of the studied group for the included studies verifying the influence of fruit and vegetables intake on the mental health in children

Ref No	Author, year	Country/ Location	Studied group of children	Number of patients (girls)	Age
[1]	<i>Banta et al. 2013</i>	USA/ California	5-11 years	11,190 (5,442)	5-11 years
[3]	<i>Cartwright et al. 2003</i>	UK/ South London	Children observed for 8 years from the age of 11-12 to 15-16	4,320 (1,742) at baseline	11.8 ± 0.3
[4]	<i>Clevenger et al. 2018</i>	USA/ Flint, Michigan	Children from 4 th -6 th grade	754 (354)	8-13 years
[5]	<i>Dennison-Farris et al. 2017</i>	USA/ Oklahoma	American Indian children	121 (73)	10.5 ± 1.6
[14]	<i>Kim et al. 2017</i>	Korea/ Seoul	6-19 years	318 (168)	11.8 ± 3.6
[15]	<i>Kohlboeck et al. 2012</i>	Germany	Children	3,361 (1,649)	11.2 ± 0.5
[16]	<i>McMartin et al. 2012</i>	Canada/ Nova Scotia	10-11 years	3,757 (1,954)	10-11 years
[17]	<i>Michels et al. 2012</i>	Belgium	5-12 years	437 (219)	Median of 8.96 (girls)/ 9.02 (boys)
[19]	<i>Oellingrath et al. 2013</i>	Norway/ Telemark County	12-13 years	789 (393)	12-13 years
[21]	<i>Renzaho et al. 2012</i>	Australia/ Victoria	4-12 years	3,370 (1,625)	4-12 years
[28]	<i>Wu et al. 2016</i>	Taiwan/ Taipei city and Hsinchu County	Children observed for 8 years from the age of 8-9 to 16-17	2,259 (1,129)	8-17 years
[29]	<i>Yu et al. 2018</i>	China/ Wuhan	Obese children	188 (42)	9.8 ± 0.7

The assessment of the fruit and vegetable dietary intake and the psychological outcome for the included studies verifying the influence of fruit and vegetables intake on the mental health in children is presented in Table 3.

The results and conclusions for the included studies verifying the influence of fruit and vegetables intake on the mental health in children are presented in Table 4.

Table 3. The assessment of the fruit and vegetable dietary intake and the psychological outcome for the included studies verifying the influence of fruit and vegetables intake on the mental health in children

Ref No	Applied method of fruit and vegetable dietary intake assessment	Potentially included juices and other fruit/ vegetable products	Assessed outcome	Psychological measure of outcome
[1]	Question about number of servings yesterday with the serving size	100% fruit juice included to the study	Mental health	Strengths and Difficulties Questionnaire (SDQ)
[3]	Food frequency questionnaire with 34 food items; Dietary Instrument for Nutrition Education (DINE) – 2 items for typical frequency of consumption of fruit and vegetables	-	Perceived stress	Perceived Stress Scale (PSS)

Ref No	Applied method of fruit and vegetable dietary intake assessment	Potentially included juices and other fruit/ vegetable products	Assessed outcome	Psychological measure of outcome
[4]	The School Physical Activity and Nutrition Survey	-	(1) Mindfulness (2) Health-related quality of life	(1) The Child and Adolescent Mindfulness Measure (2) Kidscreen-27
[5]	Items from the Youth Risk Behavior Surveillance survey – question about the typical frequency of consumption	Sweetened juices not included to fruit/ vegetables but to sugar-sweetened beverages	Depressive symptoms	Child Depression Inventory (27-items)
[14]	Food frequency questionnaire with 76 food items	-	(1) Depression symptoms (2) Anxiety	(1) Child Depression Inventory (CDI) (2) State–Trait Anxiety Inventory–State (STAI-S)/ State–Trait Anxiety Inventory–Trait (STAI-T)
[15]	Food frequency questionnaire with 82 food items	Fruit juices/nectars not included to fruit/ vegetables but to beverages	Behavioral problems	Strengths and Difficulties Questionnaire (SDQ)
[16]	Harvard Youth/Adolescent Food Frequency Questionnaire (YAQ)	-	Internalizing disorders (symptoms of depression and anxiety: low mood, inhibition, excessive worrying, physical complaints, trouble sleeping, shyness)	Diagnosis based on International Classification of Diseases (ICD-9/ ICD-10)
[17]	The Children’s Eating Habits Questionnaire – Food Frequency Questionnaire (FFQ)	Fruit and vegetables including freshly squeezed fruit juice	(1) Problems (2) Life events (3) Daily events: hassles and uplifts (4) Emotions (5) Coping	(1) Strengths and Difficulties Questionnaire (SDQ) (2) Coddington Life Events Scale for children (CLES-C) (3) Children’s daily hassles (CHS) and daily uplifts (CUS) scales (4) Likert-scale for how they felt recently (5) Question about what they usually do when confronted with problems or when are upset
[19]	Food Frequency Questionnaire to assess dietary patterns including ‘Varied Norwegian’ dietary pattern (recommended nutrient-dense foods like fruits, vegetables, unrefined grains and fish combined with regular meals)	-	Mental health problems	Strengths and Difficulties Questionnaire (SDQ)
[21]	Question about the typical number of servings per day	Diced, canned and dried fruit included to fruits	Child behavior difficulty	Strengths and Difficulties Questionnaire (SDQ)
[28]	Unhealthy eating behaviors measured with three questions (fast foods, snacks, sugar sweetened beverages)	Sweetened juice included to sugar sweetened beverages	Depressive symptoms	Kovacs’ Children’s Depression Inventory (CDI)/ Center for Epidemiological Studies Depression Scale for Children
[29]	Question about the typical number of servings per day during the last month	-	(1) Well-being (2) Depressive symptoms	(1) WHO-5 well-being index (WHO-5) (2) Depression Self-rating Scale for Children (DSRSC)

Table 4. The results and conclusions for the included studies verifying the influence of fruit and vegetables intake on the mental health in children

Ref No	Results	Conclusions
[1]	Adjusting for relevant socio-demographic characteristics, logistic regression found poor mental health to be significantly associated with no consumption of vegetables (OR 0.6, $p=0.005$) on the previous day.	Children with poor mental health are more likely to consume calorie-dense but nutrient-poor foods compared to their counterparts. Intake of such foods may contribute to worse physical health as these children mature.
[3]	Girls reported more stress than boys, $t(3709) = -4.39$, $p < 0.01$ (two-tailed), $d = 0.15$, and a higher fruit and vegetable intake, $t(4145) = -2.23$, $p = 0.03$ (two-tailed), $d = 0.07$. In the multivariate analyses, higher perceived stress was associated with an increased likelihood of being in the unhealthy outcome group (Wald statistic) for fruit and vegetable consumption, $\chi^2(4) = 13.68$, $p < 0.01$ while simultaneously controlling for gender, weight, ethnicity, and SES. A trend also emerged for fruit and vegetable intake, for which greater stress was associated with a reduced likelihood of consuming five or more fruit and vegetables daily.	Stress may contribute to long-term disease risk by steering the diet in a more unhealthy direction.
[4]	Mindfulness was unrelated to both vegetable and fruit intake.	Mindfulness was positively related to psychological quality of life and inversely related to junk food intake and parent- and autonomy-related quality of life.
[5]	Depressive symptoms in children were not associated with consumption of fruit, salad, potatoes, carrots, other vegetables, sweet juice, as well as fruit and vegetables intake combined.	Depressive symptoms were associated with dieting and screen time.
[14]	Higher scores on the CDI, STAI-S, and STAI-T indicate negative emotions, and these scores were significantly decreased from the first to the fourth quartiles. Intakes of natural foods such as legumes and fruits correlate with lower theta/beta ratios ($p < 0.05$).	There is a link between overall nutritional behavior, and emotion in apparently healthy children.
[15]	A higher diet quality score was associated with lower likelihood of emotional symptoms (OR adj 0.89, 95% CI 0.80–0.98). The unadjusted significant relationship between diet quality and hyperactivity/inattention was attenuated by adjusting for several confounders to an OR adj of 0.92 (95% CI 0.82–1.03).	Lower diet quality is associated with a higher likelihood of emotional symptoms in children.
[16]	Diet quality was not found to be associated with internalizing disorder in a statistically significant manner (incidence rate ratio = 1.09; 95% CI 0.73–1.63). However, relative to children with little variety in their diets, children with greater variety in their diet had statistically significant lower rates of internalizing disorder in subsequent years (incidence rate ratio = 0.45; 95% CI 0.25–0.82).	Findings suggest the importance of variety in children's diet and opportunities in the prevention of adolescent depression and anxiety.
[17]	Negative associations were observed between events and fruit and vegetables consumption. Overall, stress was associated with a more unhealthy dietary pattern and could thus contribute to the development of overweight, also in children.	These results highlight the importance of stress reduction and the related unhealthy behavior.
[19]	Children with high scores on a 'varied Norwegian' eating pattern were less likely to have indications of any psychiatric disorders (adjusted OR=0.5; 95% CI 0.3–1.0) and hyperactivity-inattention disorders (adjusted OR=0.4; 95% CI 0.2–0.8) than children with low scores on this pattern.	There was a significant association between eating patterns and mental health problems in young adolescents, independently of physical activity, sedentary activity and background variables. A diverse diet rich in unrefined plant foods, fish and regular meals was associated with better mental health, while energy-dense, nutrient-poor diets and irregular meals were associated with poorer mental health.
[21]	Children with behavior difficulties and low levels of prosocial behaviors consumed fewer servings of fruit and vegetables than children who did not experience any behavioral problems. Child behavioral problems were associated with fruit and vegetables consumption.	Programs aimed at promoting fruit and vegetables consumption in children should target those families with children experiencing behavioral problems.

Ref No	Results	Conclusions
[28]	The frequency of unhealthy eating behaviors in the previous year and the difference between the frequency in the previous and successive year were positively associated with the initiation and growth rate of depressive symptoms. Depressive symptoms in the previous year and the difference in depressive symptoms between the previous and successive year were positively associated with the initial state and growth rate of unhealthy eating behaviors.	There is a reciprocal relationship between depressive symptoms and unhealthy eating behaviors.
[29]	Sufficient fruit and vegetables intake was associated with significantly decreased risk for depressive symptoms (OR: 0.21, 95% CI: 0.08–0.55). Interactive inverse associations were observed between combined high physical activity and sufficient fruit and vegetables intake with poor well-being (OR: 0.16, 95%CI: 0.05–0.55) and depressive symptoms (OR: 0.12, 95% CI: 0.03–0.48).	High physical activity and sufficient fruit and vegetables intake are inversely associated with the risks of poor well-being and depressive symptoms among obese Chinese schoolchildren.

DISCUSSION

Majority of the included studies, were conducted in USA [1, 4, 5], European countries [3, 15, 17, 19], or Asian countries [14, 28, 29], but also in Australia [21] and Canada [16], mainly in a population of preschoolers and school-aged children [1, 4, 5, 15-17, 19, 21, 29], but also in a general population of children [3, 14, 28]. Among the included studies, one was conducted in a specific group of obese children [29] and one in a specific group of those of American Indian ethnicity [5].

While the fruit and vegetable intake was assessed, some authors included the fruit and vegetable processed products, such as 100% juices [29], freshly squeezed fruit juices [17], but also a dried or canned ones [21], while a number of them indicated sweetened juices as a separate group [5, 15, 28]. Some authors assessed rather general dietary patterns, which included fruit and vegetables intake among other elements of it, such as ‘varied Norwegian’ dietary pattern (characterized by the content of fruit, vegetables, unrefined grains and fish combined with regular meals) [19], or did not include fruit and vegetables intake among other elements of it, such as ‘unhealthy’ dietary pattern (characterized by the content of fast food, snacks, sweetened beverages) [28].

While the mental health was assessed, the varied elements and a wide area of it were included, such as a general well-being [29], mental health [1], or emotions [17], but also a mindfulness [4], or negative issues, such as problems [17, 19], stress [3], life events [17], behavioral difficulties and problems [15, 21], as well as depressive symptoms [5, 28, 29], or depressive symptoms combined with anxiety [14, 16].

In spite of the fact that a number of included studies, namely 12 studies, was relatively small, there were some coincident observations, that may indicate that for this specific population, the fruit and vegetable intake as an element of general healthy diet may be perceived as this which contributes better mental health. It was stated, that sufficient fruit and vegetables intake was associated with significantly decreased risk for depressive symptoms, but it was especially beneficial

while combined with physical activity, as in such case it also promoted a better well-being [29]. It was also associated with decreased risk of behavior difficulties [21]. In general, the association was especially visible for vegetables [1] and was indicated not only for general amount of consumed fruit and vegetables, but for the obtaining a recommended 5-a-day recommendation [3].

In other studies, not only fruit and vegetables intake but the general beneficial dietary patterns were associated with the reduces mental health problems [17], lower likelihood of emotional symptoms [15], negative emotions [14], internalizing disorders [16], depressive symptoms [28], and psychiatric disorders [19].

However, it must be emphasized, that in some studies the association for fruit and vegetables intake was not statistically significant and it was not proven, that they may promote a better mental health [4, 5].

CONCLUSIONS

In majority of studies included to the systematic review of the observational studies analyzing the association between the fruit, vegetables and the products (including juices) intake and the mental health in pre-schoolers and school-aged children, the supposed positive influence was confirmed. However, it must be indicated that it was studied only in a few research and the issue must be analyzed in other populations. At the same time, in a number of studies, not fruit and vegetables intake alone was stated to be beneficial, but rather a more general dietary pattern, including also other elements of healthy diet and healthy lifestyle.

Acknowledgements

The study was supported by the Certified Product ‘CP’ Quality System (CEN.DRR.WFP.705.350. 2018. MR.3) within the National Polish Promotion Fund for Fruits and Vegetables Consumption. The funders had no role in the design of the study, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

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Received: 22.11.2019

Accepted: 20.12.2019