The Promotion of Physical Activity and Health-Related Factors during Pandemic for Children and Adolescents: A Review Article

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Abstract

**Background:** Regularly performed physical activity promote proper development and prevent health risk factors in children and adolescents. Pandemic crisis has been limiting the scope of movement with social distancing for participation of physical activity for health promotion. This study aimed to review studies on promoting physical activity to prevent health risks for children and adolescents since the onset of COVID-19.

**Methods:** Three major online databases (PubMed, Medline, and Scopus) were searched for ‘physical activity,’ ‘intervention’ for children and adolescents. Seven articles were selected from 1,761 articles through the inclusion and exclusion processes.

**Results:** All studies were conducted through online. One study showed that streaming services and online apps majorly promoted MVPA (moderate-to-vigorous physical activity), MSE (muscle-strengthening exercise), or combined (MVPA, MSE) by 2.4, 3.1, and 4.3 folds, respectively. Another study showed that greater duration of physical activity (PA) prevented depressive symptoms during exposure to outbreak. Five intervention studies which used digital platforms to promote PA significantly encouraged PA along with the physiological, psychological, and academic achievement outcomes.

**Conclusion:** Internet-based digital platforms may assist to promote physical activity for improved psychosocial and academic achievement in children and adolescents during the unack period. Structured PA promotion platforms with various health outcomes for children and adolescents should be developed and scientifically evaluated.

**Keywords:** Children; Adolescents; Physical activity; Health promotion; COVID-19

Introduction

Special health care should be provided for appropriate growth and development of children and adolescents into their adulthood (1). Special care includes supporting to obtain sufficient mental health care, nutritional support, and physical activity among others (1-4). Parents, caregivers, and various experts have been trying to provide the best for children and adolescents from all over the world. However, the pandemic outbreak has altered and limited the means to cater the developmental needs of the children and adolescents (5-7).

To avoid the spread of the corona virus, assorted preventative measures have been implemented by
the authorities from all corners of the world. School closure, lockdown, and social distancing have been forcefully stipulated to unavoidably participate in the extend homeschooling, home confinement, and limited scope of movement (7, 8). On top of such restrictions, most of the outdoor as well as indoor activities have also been impeded to prevent close contact with others in response to COVID-19.

All the contagion preventative measures have led to compelling reduction in the amount health promoting activities of everyone including children and adolescents (7). Assorted health deterring problems have been reported through prolonged impeding behaviors and restrictions may lead to long-term health-related complications (2, 9, 10). Physical inactivity and weight gain are among the major long-term health deterring concerns (5). Many recent pandemic related reports showed drastic increase in inactivity and health management concerns (5, 7, 8, 11). Home confinement of the children and adolescents have also been known to gain weight and lead inactivity followed by various health concerns (8).

Undetermined duration of the pandemic situation is aggravating the health risks for children and adolescents (7, 9, 10, 12, 13). Current pandemic situation which first believed to be a transient problem is becoming a long-term obstacle with emergence of corona virus variants. Among other problems, physical inactivity and overweight have been known to be major risk factors in promoting severe COVID-19 infection and increasing mortality even in children and adolescents (5, 7). Therefore, promoting physical activity and reducing sedentary lifestyle during the time of pandemic crisis is vital in promoting healthy growth into the adulthood.

Although a considerable number of studies along with review articles have been conducted to observe and promote psychological and mental health of the adolescents, articles on promoting physical activity and sedentary lifestyle, especially review articles were scarce (10, 12, 14). Means to promote physical activity for general health concerns for children and adolescents are limited during the ongoing untact period. Scientific methods should be provided to promote physical activity for health risk prevention for children and adolescents. Therefore, this study aimed to analyze major online databases (PubMed, Science Direct, and Scopus) to search original studies on promoting health through physical activity in children and adolescents.

**Methods**

This study was conducted by searching three major online databases that included PubMed, Science Direct, and Scopus using the key terms “physical activity” and “exercise” with the following search terms: “intervention” and “COVID-19 from 2020-2021” Either the terms “adolescents,” “children,” or “youth” were alternatively used to widen the search. Articles were selected based on the inclusion and exclusion criteria. Inclusion criteria included the followings: (a) scientific research articles searched based on the terms mentioned, (b) children and/or adolescents, (c) articles that analyzed health-related physical activity, (d) studies conducted after the onset of COVID-19 outbreak, (e) study design of either randomized control trial, experimental, cross-sectional, or longitudinal study, and (f) healthy subjects. There were exclusion criteria for further filtering of the studies were as followed: (a) case studies, review articles, meta-analysis articles, letters, proceedings, master or doctorate’s thesis, and editorials, and (b) specially targeted subjects with clinical problem.

Search of the published literatures since 2020 yielded 32 articles from PubMed, 29 articles from Science Direct, and 1,700 articles from Scopus. A total of 1,762 articles were first reviewed and manually filtered out for the title to exclude overlapping of the articles. Further filtering was performed by reviewing the abstracts and main body of the articles if necessary. All possible articles were thoroughly reviewed.

The entire contents of remaining 26 articles were reviewed to confirm the inclusion criteria such as the study dates and study subjects. Although 19 articles were published after the initial outbreak
(years 2020 and 2021), actual tests were conducted prior to COVID-19. Seven articles met the inclusion criteria and were selected for this study (Fig. 1).

![Flowchart of the article select process](image)

**Results**

A total of seven articles were selected out of initial 1,761 articles. Selected 7 articles were composed of 3 randomized control trial, 2 longitudinal survey, 1 cluster control trial, and 1 cross-sectional survey studies. The number of subjects ranged from 15 to 1,487 and the age ranged from 7 to 17 years (Table 1).

First study conducted was performed with 42 adolescents between the age of 13 to 16 years in the UK and Ireland (15). Moderate-to-vigorous physical activity (MVPA) was performed through 30-minute live physical activity sessions. Weekly behavior change support video calls were provided (1×30 min, 6×10 min) with text messages (3 per week) to promote participation. The intervention group (n=22) significantly showed improvements in physical fitness variables ($P=0.022$ to $P=0.001$) and psychosocial outcomes ($P=0.037$ and $P=0.001$) (Table 2).
Table 1: Characteristics of the selected studies

| Reference | Study Type According to Protocol | Study completion Date and Duration | Subjects | Study location |
|-----------|---------------------------------|-----------------------------------|----------|----------------|
| (15)      | Randomized controlled trial     | April and May, 2020, Duration: 6 weeks | Age range: 13-16 years, mean age: 14.2±1.1 years, HERizon intervention (n=22), control (n=20) | UK and Ireland |
| (16)      | Cluster control trial           | Date: 16 March 2020, duration: 2 weeks | Planned number (n): 954, Mean age: 13.5(±0.5) years, grades: 7-12, Intervention (n=485), Control (n=469) | Zhaoqing city, China |
| (17)      | Randomized control trial        | Date: 2020, Duration: 3 months     | Age range: 15-17, mean age: 16.29±0.57 years, Grades: 10-11, intervention (n=36), control (n=32) | Gonbad Kavoous city, Iran |
| (18)      | Randomized controlled study     | Oct and Dec 2020, Duration: 8 weeks | Age range: 14-15 years, mean age: 14.53±0.50, intervention (n=15), control (n=15) | Italy |
| (19)      | Longitudinal study              | May 4-31, 2020.                    | Digital platform users (n=255), age: 16.2 (1.3) years, non-users (n=708), age: 16.3 (1.2) years | Australia |
| (20)      | Cross-sectional survey study    | April 19-26, 2020, Duration: 7 days | Age range: 10-17 years, mean age: 13.20±1.45 years, Adolescents living in quarantine: n=171 (1,316) | Zhengzhou city, China |
| (21)      | Longitudinal study              | Sept 24-Nov 3, 2020, Duration 7 weeks | Age range: 6 to 13 years, mean age: 9 years, n=53 | Los Angeles, USA |

PA: physical activity, PE: physical education

Second study, a cluster randomized controlled trial, was performed with 896 adolescents (16). Peer-to-peer live stream application was used during recessions of the daily online classes. Self-performed physical activity and sharing through online during recessions significantly reduced anxiety (P=0.02) and eye strain (P=0.02).

Third study was performed with 68 Iran high school students (17). Intervention group (n=36) participated the online physical education classes and performed 2 sessions per week for 3 months. Perceived autonomy support (F=292.44, P<0.001), intrinsic motivation (F=466.82, P<0.001), level of physical activity (F=113.48, P<0.001), self-reported physical activity (F=113.48, P<0.001), and intention to physical activity (F=82.50, P<0.001) all significantly improved.

Fourth study was conducted with 30 local high school students in Italy (18). Online at-home workout program was provided twice a week for 60 minutes of supervised training (EG) and theoretical knowledge (CG) education. Significant improvements were shown in physical fitness variables and body composition (all P<0.001).
Table 2: Intervention methods and physical activity and health-related outcomes

| Reference | Tools and Interventions | Physical activity and outcomes | Health-related outcomes |
|-----------|--------------------------|-------------------------------|-------------------------|
| (15) HERizon Project; three 30-minute PA sessions per week performed. Weekly home-based online group exercises, behavior change support video calls (1×30 min, 6×10 min) and text messages (3 per week) made by activity mentors | Self-reported habitual PA (P=0.767), cardiorespiratory fitness (20 m shuttle run) (P = 0.001), muscular strength (standing long jump) (P = 0.022), intrinsic motivation (P=0.037), and body appreciation (push up test) (P=0.022) | Psychosocial outcomes: intrinsic motivation (0.16 vs. 0.16; P=0.037) and body appreciation (0.44 vs. 0.11; P=0.003). |
| (16) Tool/method: REAP (Recess and Exercise Advocacy Program) peer-to-peer live-streaming app, Intervention: self-reported physical activity during recess | Physical activity: stretching and home exercise during four 15-minute recesses per day | Manifest of anxiety difference –0.36, 95% CI –0.63 to –0.08; P=0.02), eye strain (intervention group: –0.08, 95% CI –0.10 to 0.06; control group: 0.07, 95% CI 0.05-0.09; difference –0.15, 95% CI –0.26 to –0.03; P=0.02), P=0.23, screen time (P=0.84), reading time (P=0.47) |
| (17) Tool/method: 2 session per week physical education class via WhatsApp mobile app with for 3 months | Intention to physical activity (F=113.48, P<0.001), self-reported physical activity (F=113.48, P<0.001), and intention to physical activity (F=82.50, P<0.001) | Perceived autonomy support (F=292.44, P<0.001), intrinsic motivation (F=466.82, P<0.001), |
| (18) At-home online workout program twice a week for 60 min, structured physical education program as part of school lessons | Motor tests (Standing long jump test (P<0.001), Harvard step test (P<0.001), sit and reach test (P<0.001), and butt kicks test (P<0.001)) | Academic achievement test (Amos 8-15) for assessment of study skill (all P<0.001): motivation, organization, study flexibility, concentration, anxiety, and BMI. |
| (19) Data from Our Life at Home study (OL@H), Adherence to physical activity guidelines by digital platforms | MVPA (OR 2.4, 95% CI 1.3-4.3), MSE (OR 3.1, 95% CI 2.1-4.4), and combined (OR 4.3, 95% CI 2.1-9.0) guideline adherence compared to non-users | Major services are streaming services (ex. YouTube, Instagram, Facebook): 102/255, 40.0%, facilitated online classes via an app or online (ex. MyFitnessPal): 77/255, 30.2%), subscriber fitness programs (ex. Zoom): 35/255, 13.7%. |
| (21) Effects of at-home physical activity (eg, workout, outdoor walking, jogging, etc.) level of PA level 1(<0.5), PA level 2 (0.5-1 h), PA level 3 (1-2 hrs), PA level 4 (>2 h per day) on depressive symptoms. | PA without 2.18±0.79 h and PA with infection (2.14±0.78 h). Physical activity time (b=-0.07, P<0.001) negatively associated with depressive symptoms. | Age (b=-0.05, P<0.001), community infection (b=0.27, P<0.001), and screen time (b=-0.05, P<0.001) positively affected depressive symptoms. All 4 daily living routines (b from -.24 to .23) negatively affected symptom prevalence. Age (b=-0.07, P<0.01), PA time (b=-0.15, P<0.01), and routines (b=-0.09, P<0.01) moderated the relation between infection and depressive symptoms |
| (22) Online platform ‘Padle’ sent 7 videos (7 weeks) and 1 live 90-minute workshop to 120 adolescents. 53 youth participants reported on the virtual sport-based PYD program and 26 shared photos, images, or posts. | Positive perceptions of virtual sport-based PYD (positive youth development) activities | Life skill transfer, emotional responses, peer interactions, family engagement, and utilization of Environmental Resources. |

PA: physical activity, PE: physical education

Available at:  [http://ijph.tums.ac.ir](http://ijph.tums.ac.ir)
Fifth article observed adherence to physical activity guideline between April and May of 2020 (19). Among 963 adolescents, 255 (26.5%) reported of using online or digital platform to perform physical activity with the median frequency and duration of 4 times and 120 min per week, respectively. Streaming services were majorly used to promote MVPA (moderate-to-vigorous physical activity) and MSE (muscle-strengthening exercise) (20).

Sixth study conducted was conducted with 1,487 public school adolescents in Zhengzhou city, China (21). The adolescents were divided into those lived in the quarantine area (n=171) and non-quarantine area (n=1,316) after 2 months of quarantine period to observe effects of COVID-19 prevalence on the adolescents. Moreover, physical activity was categorized into four levels to observe the effects on the depressive symptoms. Age, physical activity, and disciplined routines significantly affected screen time (P<0.001), depressive symptoms (P<0.001), and improved all home routines (P<0.01).

Seventh study was performed with adolescents in Los Angeles, USA (22). Among the program participants, 53 youth reported their activities of the virtual sport-based PYD and 26 shared photos, images, or posts about their lived experiences. Positive perceptions of virtual sport-based PYD activities were reported from the participated adolescents. Moreover, positive life skill transfer, emotional responses, peer interactions, family engagement, and utilization of environmental resources were all reported for effectiveness of digital platform-based intervention on adolescents.

Discussion

According to UNICEF (United Nations International Children's Emergency Fund), the persisting pandemic crisis has led to repeated closure of schools in more than 200 countries. Such ongoing school closures secluded and altered lives of everyone, especially adolescents (5, 7). Isolation by school closure and social distancing led to limited scope of movement and sedentary lifestyle in in children (5, 12, 13). Sufficient and adequate support is needed to promote growth and health during the developmental stage (1, 3).

To provide scientific means to promote physical activity and prevent corresponding health risks in adolescents, this study searched three major databases for recent research articles. A total of seven articles were selected out of 1,761 articles searched from PubMed, Science Direct, and Scopus through strict inclusion and exclusion criteria. All seven studies were conducted online and interventions of five studies were performed with internet-based digital platforms. Although different programs were used, all the intervention studies used real-time intervention methods of either peer-to-peer live streaming services, physical education classes, support video calls, text messages, and/or live workshops (15-18, 22). Moreover, survey study by Parker et al. reported that the major physical activity promoting method was based on streamlining services (19).

Participation of digital platform-based physical activity has swiftly increased since the outbreak (23). Rapid advances in internet-based technology has penetrated to everyday devices to monitor and advocate physical activity and general health in everyday lives (24). Various health-related factors can be targeted for rapid development for precise management (22, 25-28). Lives of children and adolescents today are very much involved and influenced by internet-based interactions. Extended homeschooling and social distancing aggravated the reliance on the internet-based interactions. Promotion of health promoting behaviors through digital platform seems unavoidable (27, 29). However, although promoting health behavior in children and adolescents via internet-based devices have previously been positively reported (25, 30), most are trial-based platforms or designed for limited group of individuals. Moreover, most of the studies do not include physical activity programs to meet the suggested physical activities guidelines (2). Most of the targeted children and adolescents for the digital platform studies were subjects with clinical complications including mental health (12, 27, 31). Physical activity is also known to improve academic outcomes that includes school perfor-
mance, memory, execution, and motivation (2, 32, 33). Most of the articles that are included in this study also positively reported on improved cognitive function and academic outcomes through physical activity participation (15-18, 21, 22).

The studies reviewed in this study reported of improvements in various health outcomes through increased physical activity. Improved health outcomes include reduced anxiety and negatively affected depressive symptoms (21). Psychosocial improvements, including autonomy support, intrinsic motivation, and body appreciation were among the outcomes (15-17). Study skill improvements include motivation, organization, study flexibility, and concentration were also reported. In addition, motivation to participate in physical activity, life skill transfer, emotional responses, peer interactions, family engagement, and utilization of environmental resources have also been reported (15, 19, 21, 22). Regularly performed physical activity has been known to improve almost all health aspects including physical, mental, social, and developmental factors with minimal side effects (2, 34-37). Body mass index improvement was also reported along with physical fitness variables (18). Even prior to the pandemic outbreak, physical inactivity was a global concern for the occurrence of various adult-onset complications including obesity (38, 39). Facilitated physical inactivity with obesity should also be controlled through increase physical activity. Multiple factors should be considered in designing applicable studies. Different physical activity interventions such as aerobic and strengthening activities should be considered for different aspects of health for developing children (1, 2, 20, 36, 37). Usage of digital platforms also should be carefully considered. A sudden surge of digital tool usage has also influenced and led the healthcare’s digital revolution for delivering mental and behavioral health services. However, platforms with credible contents may not be apparent (40). Moreover, digital space is like a double-edged sword: depending on the type contents provided, provided service may be helpful or harmful especially for children and adolescents (17, 26, 27, 40). Scientifically approached and designed platforms should be developed to promote proper amount of physical activity to support proper growth and prevent short- and long-term health risks for adolescents.

Factors such as age and gender may also influence the outcome of the digital platform-based intervention. For example, boys and older adolescents were reported to be inactive during pandemic compare to girls and younger children (11). It may be that boys and older adolescents are more likely to participate in organized team sports that require large space and participants (11, 41). In addition, residential environment including climate, income, race, dwelling space, density of resident area, infection cases, parental support, and family conflict among others have been reported to influence physical activity participation (11). Although abovementioned factors may be influential, mixed results have been reported with limited number of studies.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Conclusion

Promoting physical activity during pandemic was reported to be significantly influential in improving physical, mental, cognitive, and psychosocial health in children and adolescents. All the studies utilized internet-based digital platforms to conduct the studies. Effectiveness of streaming services were observed for physical activity intervention to significantly improve physical fitness and obtain physical activity related health outcomes. Applicable digital platforms should be developed with scientifically approached health-promoting considerations for children and adolescents.

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Conflict of interest
The authors declare that there is no conflict of interests.

References
1. Gonzalez-Gross M, Gomez-Lorente JJ, Valtuena J, et al (2008). The "healthy lifestyle guide pyramid" for children and adolescents. Nutr Hosp, 23(2):159-68.
2. Chaput JP, Willumsen J, Bull F, et al (2020). 2020 WHO guidelines on physical activity and sedentary behaviour for children and adolescents aged 5-17 years: summary of the evidence. Int J Behav Nutr Phys Act, 17(1):141.
3. Sisk C (2016). Promoting Children's Health-Related Quality of Life. Pediatr Nurs, 42(2):86-8.
4. Das JK, Lassi ZS, Hoodbhoy Z, et al (2018). Nutrition for the Next Generation: Older Children and Adolescents. Ann Nutr Metab, 72 Suppl 3:56-64.
5. Hall G, Laddu DR, Phillips SA, et al (2021). A tale of two pandemics: How will COVID-19 and global trends in physical inactivity and sedentary behavior affect one another? Png Cardiovases Dis, 64:108-110.
6. Golberstein E, Wen H, Miller BF (2020). Coronavirus Disease 2019 (COVID-19) and Mental Health for Children and Adolescents. JAMA Pediatr, 174(9):819-820.
7. Nogueira-de-Almeida CA, Del Ciampo LA, Ferraz IS, et al (2020). COVID-19 and obesity in childhood and adolescence: a clinical review. J Pediatr (Rio J), 96(5):546-558.
8. Cuscieri S, Grech S (2020). COVID-19: a one-way ticket to a global childhood obesity crisis? J Diabetes Metabol Disord, 19(2):1-4.
9. Zhou Y, Chi J, Lv W, et al (2021). Obesity and diabetes as high-risk factors for severe coronavirus disease 2019 (Covid-19). Diabetes Metabol Res Rev, 37(2):e3377.
10. Shah K, Mann S, Singh R, et al (2020). Impact of COVID-19 on the Mental Health of Children and Adolescents. Cureus, 12(8):e10051.
11. Yomoda K, Kurita S (2021). Influence of social distancing during the COVID-19 pandemic on physical activity in children: A scoping review of the literature. J Exerc Sci Fit, 19(3):195-203.
12. Singh S, Roy D, Sinha K, et al (2020). Impact of COVID-19 and lockdown on mental health of children and adolescents: A narrative review with recommendations. Psychiatry Res, 293:113429.
13. Guerrero MD, Vanderloo LM, Rhodes RE, et al (2020). Canadian children's and youth's adherence to the 24-h movement guidelines during the COVID-19 pandemic: A decision tree analysis. J Sport Health Sci, 9(4):313-321.
14. Deolmi M, Pisani F (2020). Psychological and psychiatric impact of COVID-19 pandemic among children and adolescents. Acta Biomed, 91(4):e2020149.
15. Cowley ES, Watson PM, Foweather L, et al (2021). Formative Evaluation of a Home-Based Physical Activity Intervention for Adolescent Girls-The HERizon Project: A Randomised Controlled Trial. Children (Basel), 8(2):76.
16. Zheng Y, Wang W, Zhong Y, et al (2021). A Peer-to-Peer Live-Streaming Intervention for Children During COVID-19 Homeschooling to Promote Physical Activity and Reduce Anxiety and Eye Strain: Cluster Randomized Controlled Trial. J Med Internet Res, 23(4):e24316.
17. Dana A, Khajehaflaton S, Salehian MH, et al (2021). Effects of an Intervention in Online Physical Education Classes on Motivation, Intention, and Physical Activity of Adolescents during the COVID-19 Pandemic. Int J School Health, 8(3):141-49.
18. Latino F, Fischetti F, Cataldi S, et al (2021). The Impact of an 8-Weeks At-Home Physical Activity Plan on Academic Achievement at the Time of COVID-19 Lock-Down in Italian School. Sustainability, 13(11):5812.
19. Parker K, Uddin R, Rodgers ND, et al (2021). The Use of Digital Platforms for Adults' and Adolescents' Physical Activity During the COVID-19 Pandemic (Our Life at Home): Survey Study. J Med Internet Res, 23(2):e23389.
20. World Health Organization (2010). Global Recommendations on Physical Activity for Health. Global Recommendations on Physical Activity for Health.
21. Ren H, He X, Bian X, et al (2021). The Protective Roles of Exercise and Maintenance of Daily Living Routines for Chinese Adolescents During the COVID-19
Quarantine Period. *J Adolesc Health*, 68(1):35-42.

22. Bates S, Greene D, O’Quinn L (2021). Virtual Sport-Based Positive Youth Development During the COVID-19 Pandemic. *Child Adolese: Social Work*, 1-12.

23. Serra G, Lo Scalzo I, Giuffre M, et al (2021). Smartphone use and addiction during the coronavirus disease 2019 (COVID-19) pandemic: cohort study on 184 Italian children and adolescents. *Ital J Pediatr*, 47(1):150.

24. Jee H (2017). Review of researches on smartphone applications for physical activity promotion in healthy adults. *J Exerc Rehabil*, 13(1):3-11.

25. Direito A, Jiang Y, Whittaker R, et al (2015). Smartphone apps to improve fitness and increase physical activity among young people: protocol of the Apps for IMProving FITness (AIMFIT) randomized controlled trial. *BMC Public Health*, 15:635.

26. Suruliraj B, Bessenyei K, Bagnell A, et al (2021). Mobile Sensing Apps and Self-management of Mental Health During the COVID-19 Pandemic: Web-Based Survey. *JMIR Form Res*, 5(4):e24180.

27. Wong CA, Madanay F, Ozer EM, et al (2020). Digital Health Technology to Enhance Adolescent and Young Adult Clinical Preventive Services: Affordances and Challenges. *J Adolesc Health*, 67(2S):S24-S33.

28. Jee H, Park J (2020). Feasibility of a novice electronic psychometric assessment system for cognitively impaired. *J Exerc Rehabil*, 16(6):489-495.

29. Cushing CC, Bejarano CM, Ortega A, et al (2021). Adaptive mHealth Intervention for Adolescent Physical Activity Promotion. *J Pediatr Psychol*, 46(5):536-546.

30. Brannon EE, Cushing CC (2015). A systematic review: is there an app for that? Translational science of pediatric behavior change for physical activity and dietary interventions. *J Pediatr Psychol*, 40(4):373-84.

31. Tornivuori A, Tuominen O, Salantera S, et al (2020). A systematic review on randomized controlled trials: Coaching elements of digital services to support chronically ill adolescents during transition of care. *J Adv Nurs*, 76(6):1293-1306.

32. Latino F, De Candia M, Morano M, et al (2021). The impact of an extracurricular outdoor physical activity program on long-term memory in adolescent during COVID-19 pandemic. *Sustainability*, 13(11):5812.

33. Poitras VJ, Gray CE, Borghese MM, et al (2016). Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab*, 41(6 Suppl 3):S197-239.

34. Bermejo-Cantarero A, Alvarez-Bueno C, Martinez-Vizcaino V, et al (2017). Association between physical activity, sedentary behavior, and fitness with health related quality of life in healthy children and adolescents: A protocol for a systematic review and meta-analysis. *Medicine (Baltimore)*, 96(12):e6407.

35. Lubans D, Richards J, Hillman C, et al (2016). Physical Activity for Cognitive and Mental Health in Youth: A Systematic Review of Mechanisms. *Pediatric*, 138(3):e20161642.

36. Hosker DK, Elkins RM, Potter MP (2019). Promoting Mental Health and Wellness in Youth Through Physical Activity, Nutrition, and Sleep. *Child Adolesc Psychiatr Clin N Am*, 28(2):171-193.

37. Alves JGB, Alves GV (2019). Effects of physical activity on children's growth. *J Pediatr (Rio J)*, 1:72-78.

38. Shin S, Jee H (2020). Prevalence of metabolic syndrome in the Gulf Cooperation Council countries: meta-analysis of cross-sectional studies. *J Exerc Rehabil*, 16(1):27-35.

39. Lee IM, Shiroma EJ, Lobelo F, et al (2012). Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*, 380(9838):219-29.

40. Psiloghos AM, Stiles-Shields C, Neary M (2020). The Needle in the Haystack: Identifying Credible Mobile Health Apps for Pediatric Populations during a Pandemic and beyond. *J Pediatr Psychol*, 45(10):1106-1113.

41. Sekulic D, Blazevic M, Gilic B, et al (2020). Prospective analysis of levels and correlates of physical activity during COVID-19 pandemic and imposed rules of social distancing; gender specific study among adolescents from Southern Croatia. *Sustainability*, 12(10):4072.