RELATIONSHIP OF SPORTS PARTICIPATION AND PHYSICAL ACTIVITY WITH INTERNET ADDICTION; A SYNTHESIS OF EVIDENCE

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ABSTRACT:

Internet addiction has widely accepted as a psychiatric condition in research literature that is often characterized by negative psychological, social, and physical outcomes. While physical activity and sports participation is considered as assistive interventions for positive psychological, physical and social variables. This review aimed to assess the evidence concerning effectiveness of physical activity to reduce internet addiction. Research articles related to goal of this review were systematically searched in the eleven research data bases such as PubMed, Science Direct, Scopus, Medline, Cochrane library, Psych INFO, ERIC, Taylor & Francis, JSTOR, Springer Link, and Google scholar, up to February, 2019. After critical appraisal, twenty articles (nineteen cross-sectional and one qualitative study) identified with low or moderate risk of bias. Results of the seventeen studies provided support in favor of statistically significant inverse association between physical activity and internet addiction and three studies did not find any relationship. The findings of this review likely to suggest the effectiveness of physical activity as preventive measure to treat the internet addiction in youth studying at schools, colleges, and universities.

Keywords: *Sports participation, exercise, internet addiction, prevention, psychological health*

Introduction:

In this technological world, use of internet has acquired importance as an integral part of human life across the globe. However, in many cases, its overuse may result in emergence of psychiatric condition that generally known as internet addiction (IA).

Irrespective of controversy on its definition; many researchers agreed that Internet addiction (IA) can be conceptualized as to keep using internet excessively despite its adverse consequences on one's psychological and physical, occupational and social do-

mains of life (Beard & Wolf, 2001; Vondráčková & Gabrhelik, 2016).

Though internet addiction has not been incorporated in the manual of psychiatric disorders (i.e., Diagnostic and Statistical Manual of Mental Disorders, 5th edition), however, a body of research literature has considered it as a major public health concern worldwide.

For example a meta-analytical study reported 6.0 percent rate of internet addiction with lowest rate in Western and Northern Europe (2.6%) and highest rate in Middle East countries (10.9%) (Cheng & Li, 2014).

The study findings further revealed that the addiction rate was 8.0%, 7.1%, 6.1%, and 4.3%, in North America, Asia, South-East Europe, and in Oceania, respectively.

These estimates of internet addiction were based on samples from general population. However, several studies involving adolescents and young adults showed that the rate of internet addiction was alarmingly higher, from 17 % to 26.8 % in Hong Kong (Shek & Yu, 2016), 6.3% in Jordan (Malak, Khalifeh, & Shuhaiber, 2017), 21.2% in Vietnam (Zhang et al., 2017), 13.9% in European countries (Artemis et al., 2014), 0% to 26.3% in USA (Moreno, Jelenchick, Cox, Young, & Christakis, 2011), 22% in Iran (Ayas & Horzum, 2013), and 3.7% in Netherlands (Kuss, van Rooij, Shorter, Griffiths, & van de Mheen, 2013).

These estimates of internet addiction are rather indicative because inconsistency in reporting internet addiction possibly originated by variations in methodologies and approaches used to assess prevalence of internet addiction. These findings collectively indicate the severity of the phenomenon of internet addiction worldwide.

Internet addiction resulted in a wide range of negative outcomes concerning psychological, social and physical domains of life.

For example, it has been consistently indicated that psychiatric disorders such as anxiety and depression (Tang et al., 2018), suicidal behavior, attention-deficit

/ hyperactivity disorder (ADHD) (Ko, Yen, Yen, Chen, & Chen, 2012; S. Park, Jeon, Bae, Seong, & Hong, 2017), and depressed mood (Liberatore, Rosario, Martí, & Martínez, 2011) coexist with intent addiction.

In addition, low self-esteem, loneliness, shyness (Ayas & Horzum, 2013; Bozoglan, Demirer, & Sahin, 2013), lack of self-control (Koo & Kwon, 2014), disturbed sleep (Sami, Danielle, Lihi, & Elena, 2018), and detrimental mental health (Lam, 2014), also found to be closely linked with internet addiction.

Other studies found associations between internet addiction with bad social relations (Ayas & Horzum, 2013), week relations with friends and family (Gur, Yurt, Bulduk, & Atagoz, 2015), social mal-adaptation (Cao, Sun, Wan, Hao, & Tao, 2011), and disturbed parents-child relations (Chi, Lin, & Zhang, 2016).

Moreover, several physical health problems including headache, back pain, obesity (Sredniawa et al., 2015), and weekend immunity, lacking in physical vigor and physiological abnormalities (Cao et al., 2011) appeared to related with internet addiction.

On the other hand, physical activity and sports participation appeared to relate with wide range of mental, physical (Penedo & Dahn, 2005), and social (Zhao & Chen, 2018) health benefits. For example, physical activity/exercise caused reduction in depression and anxiety(Newman & Motta, 2007), improve sleep (Park, 2014), mood (Anderson & Brice, 2011), enhance self-control (J.-A. Park et al., 2016), and prevent suicide behavior (Tomori & Zalar, 2000).

Sports and exercise participation also suggested to decrease loneliness, promote social skills and expand social relations (Pels & Kleinert, 2016), and improve self-esteem (Taylor & Turek, 2010). The physical advantages of sport participation and physical activity involve improvement in body composition and reduction in obesity (Basterfield et al., 2015), increased fitness (physical, cardio-respiratory) (Garber et al., 2011), and strengthening immune system (García et al., 2014).

More importantly, evidence demonstrated that the increased time spending on internet/ online resulted in increased sedentary behavior, over weightiness and internet addiction (Choi et al., 2015; Park, 2014; Tonioni et al., 2012).

In contrast, reduction in time spent on internet have been reported as result of increased participation in sports and physical activity (Ting, Chien, Dhir, & Chen, 2018; Vandelanotte, Sugiyama, Gardiner, & Owen, 2009) and, thus, may contribute to prevent internet addiction.

These findings collectively suggest that the physical, psychological, and social disorders/ problems associated with internet addiction have inverse relationship with participation in the certain level of sport, exercise and physical activity.

If participation in sport and physical activity improve negative psychological conditions (i.e., depression, anxiety, stress, suicide thoughts, loneliness, low self-esteem, sleep) and the same psychological disorders characterized by internet addiction (as demonstrated by previous research), then, exercise and sport participation can be a potential candidate to become the part of interventional strategies when dealing with the issue of internet addiction.

Exercise and sports participation possibly exert counter effect co-morbidities of internet addiction or offset the negative psychological, social and physical outcomes of internet addiction or improve coping capacity of internet addicts that may further helps to reduce, prevent or treat internet addiction.

Therefore, it seems plausible to utilize sport, exercise, and physical activity as interventional strategy for prevention and treatment of internet addiction and can contribute to reduce online time spending.

In this context, Cooney et al. (2013) conducted a meta-analytic study to evaluate associations of physical activity with depression.

The analysis of 37 intervention studies revealed that exercise (small to moderate) proved to be

an effective strategy to reduce the symptoms of depression.

However, a recent review of reviews demonstrated that physical activity had strong effect to reduce depression and anxiety, and enhance self-esteem (Dale, Vanderloo, Moore, & Faulkner, 2018).

Moreover, another review assessed effectiveness of physical activity intervention to improve sleep quality by including nine studies with 557 participants (Banno et al., 2018).

Thy results of that review revealed that participation in exercise and physical activity has significantly positive effect to improve quality of sleep.

Similarly, with regard to suicide thoughts, another review study selected 21 studies assessing relationship of physical activity and sports participation on suicide ideations (Vancampfort et al., 2018).

The analysis revealed that there was significantly inverse relation between level of physical activity and suicide thoughts.

Findings from the previous reviews suggest that exercise can have positive effect on internet addiction.

As per, our knowledge, no review exists to date that systematically addressed this issue. To fill the research gap, this review is aimed to assess the relations of sports participation, exercise and physical activity with internet addiction.

Moreover, another purpose of this present review is to recognize the gaps for future research.

Methodology

Study inclusion and exclusion criteria

The eligibility criteria for included studies were as follows:
1) published until September 2018; 2) English language; 3) studies with any design (e.g., cross-sectional, case-control, longitudinal, intervention, cohort and qualitative) that assessed associations of physical activity, exercise, sports participation, sedentary behavior, and physical fitness with internet addiction; 4) participants with all ages and

genders; 5) studies included participants with normal health and mild psychological problems; and 6) full length articles in English language.

Excluding criteria included: 1) papers published in conference proceedings, thesis and dissertations, unpublished articles, letters, lectures and addresses, guideline statements, book chapters and books, editorials, meeting abstracts, and commentaries; 2) case reports, clinical practice guidelines, pilot studies, studies in languages other than English; 3) studies recruited participants with serious illness or physical injury; studies assessed online gaming addiction or internet gaming addiction; and 4) studies having missing important details regarding methodology.

Literature search strategy

A systematic procedure was followed to search the relevant studies using online resources including PubMed, Science Direct, Scopus, Medline, Cochrane library, Psych INFO, ERIC, Taylor & Francis, JSTOR, Springer Link, and Google scholar, up to February, 2019.

Search strategy involved using two sets of terms. For example, internet addiction related search terms such as "internet addiction", "pathological internet use"," online addiction"," excessive internet use", "Internet disorder", OR "problematic internet use", were combined with the physical activity related search terms including "exercise", "sports participation", "outdoor games playing", "physical activity", "physical fitness", OR" sedentary behavior".

Additionally, the literature concerning internet addiction in athletes versus non-athletes was also searched in the databases. Lastly, the bibliography of each relevant article and book was also screened to identify more related studies.

Study selection

The screening process for selection of admissible studies involved screening of the titles and abstracts containing relevant search terms.

Following, full articles were retrieved and performed screen-

ing process carefully to identify the relevancy of the studies.

Articles that match the eligibility criteria set for this review were considered for final selection and for further evaluation. This procedure resulted in identification of 20 studies in which 19 studies were cross-sectional plus one study was qualitative (for full detail see Figure 1

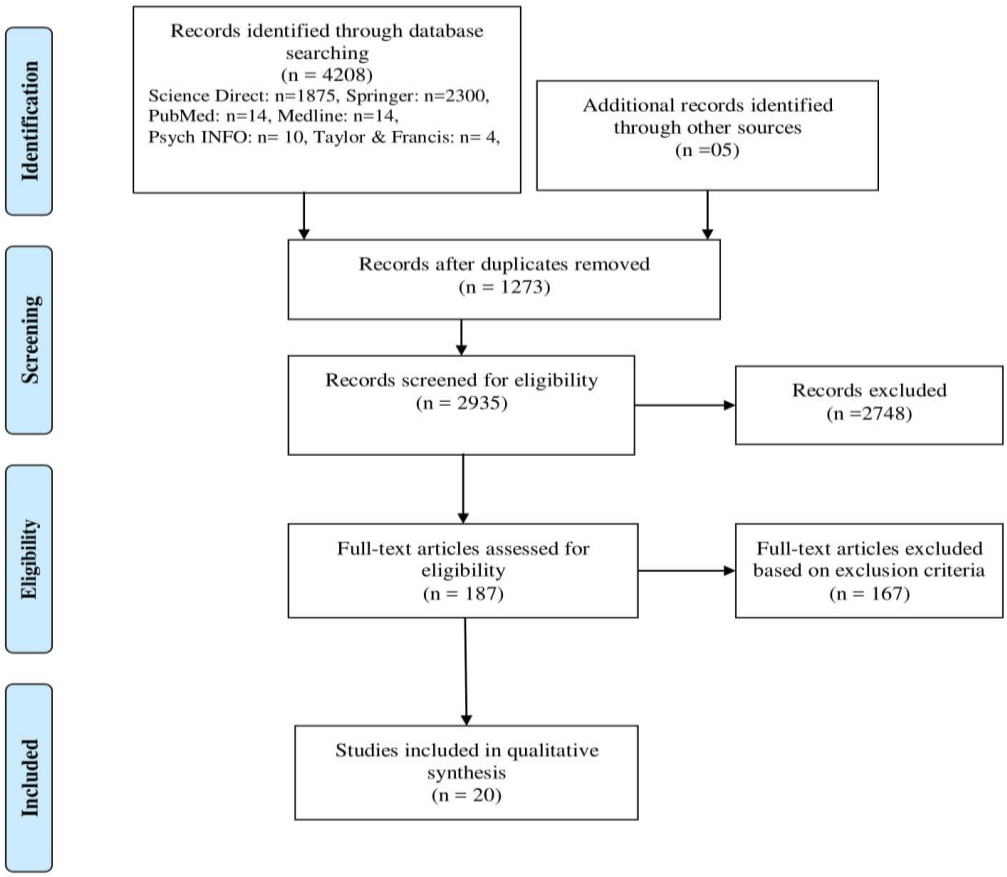

Figure 1.PRISMA flow chart showing procedure for litrature search and selection of studies assessed relation between physical activity and internet addiction

Quality assessment

Based on the inclusion criteria the identified studies were critically evaluated by two independent expert reviewers.

The risk of bias appraised independently by the reviewers for each of the selected study and they developed consensus with mutual discussion in case appearance of any discrepancy.

For quality assessment of cross-sectional studies the modified version of Newcastle-Ottawa Quality Assessment Scale for cross-sectional studies (Herzog et al., 2013).

However, the quality of the qualitative study was evaluated using the criteria described in table 2.

Based on these assessment tools, the quality scores for each included study was calculated according to coding manuals of the tools and studies were classified in terms of good, fair, and poor categories, respectively.

Studies with low and moderate risk of bios that were categorized as good and fair were finally considered to include in the review.

Studies having higher risk of bias and classified as poor category were excluded from the final analyses.

Data extraction and synthesis of results

The data was extracted from the studies classified as good and fair category to develop evidence table.

Study characteristics such as, study design, author, year of publication, country of publication, sample selection procedure, sample size, participants age, physical activity and internet addiction measures, analysis and results were drawn following careful review of the included studies (see table 1).

The drawn study characteristics were checked independently by another reviewer and differences were resolved through discussion.

Based on the criteria of best evidence synthesis, a qualitative synthesis was presented from the results of the included studies.

Results

Study Selection

4208 research citations were screened to assess eligibility for inclusion in this review of these, 2935 titles and abstracts were removed after screening and after that 187 full length articles were available that were screened based on exclusion and inclusion criteria determined for this review.

Finally, after the screening process, 26 studies met the inclusion criteria that were ultimately selected for critical evaluation. Of these, 20 studies identified as good or fair category that were chosen for qualitative synthesis in this review (see figure 1 for full description).

Study Characteristics

Among the twenty selected studies for this review, nineteen studies were cross-sectional except one study (Li, O'Brien, Snyder, & Howard, 2015)that used qualitative approach.

There were no longitudinal, intervention/experimental or cohort study eligible for inclusion in the review. The description of studies characteristics has been shown in table 1.

Of the nineteen cross-sectional studies, eleven studies in this review used systematic sampling approach (Karamitsa & Skordilis, 2015; Ayas & Horzum, 2013; Bener, Al-Mahdi, & Bhugra, 2016; Bener & Bhugra, 2013; Bener et al., 2018; Durkee et al., 2016a; Islam & Hossin, 2016; Lam, Peng, Mai, & Jing, 2009; Park, 2014; Tabatabaee, Rezaianzadeh, & Jamshidi, 2018; Yeh, Lin, Tseng, & Hwang, 2012).

In addition, four studies used convenience sampling (Dilshad, Mahabub-Ul, Fazle, Ahmed, & Hossain, 2017; Khan, Shabbir, & Rajput, 2017; Koca & Berk, 2018; Park et al., 2016) and one study used respondent-driven sampling technique (Dang et al., 2018).

Whereas, other studies used universal sampling (Sahin & Lok, 2018) and purposive sampling or other sampling approaches (Sulania, Sachdeva, & Dwivedi, 2016; Ting et al., 2018).

With regard to ages of participants, twelve studies were conducted in adolescents (Karamitsa & Skordilis, 2015; Ayas & Horzum, 2013; Bener et al., 2016; Dilshad et al., 2017; Durkee et al., 2016a; Khan et al., 2017; Koca & Berk, 2018; Lam et al., 2009; Park, 2014; Tabatabaee et al., 2018; Yeh et al., 2012) and two studies used adolescents and young adults as their participants (Bener & Bhugra, 2013; Dang et al., 2018).

Whereas, participants of three studies were selected from emerging adults (Bener et al., 2018; Sulania et al., 2016; Ting et al., 2018) and three studies selected the sample from adults population (Islam & Hossin, 2016; Li et al., 2015; Sahin & Lok, 2018).

Thus, the participants of seventeen studies (85%) out of twenty studied consisted of young people with the ages ranged from 13-25 years.

Regarding sample size of the cross-sectional included studies, the sample of five studies used large size sample (Ayas & Horzum, 2013; Bener & Bhugra, 2013; Bener et al., 2018; Durkee et al., 2016 a; Park, 2014) and the samples of four studies had medium or sufficient sizes of samples (Bener et al., 2016; Koca & Berk, 2018; Lam et al., 2009).

Whereas, ten studies used small samples size in their investigations (Karamitsa & Skordilis, 2015; Dang et al., 2018; Dilshad et al., 2017; Khan et al., 2017; Park et al., 2016; Sahin & Lok, 2018; Sulania et al., 2016; Tabatabaee et al., 2018; Ting et al., 2018).

Six studies used valid and reliable physical activity measures (Karamitsa & Skordilis, 2015; Bener & Bhugra, 2013; Dang et al., 2018; Park et al., 2016; Sahin & Lok, 2018; Ting et al., 2018), two studies used single or two items from valid and reliable physical activities measures (Durkee et al., 2016a; Sulania et al., 2016) and a physical activity measure with validity and reliability determined by the authors was used in one study (Ayas & Horzum, 2013).

However, ten studies used invalid and unreliable physical activities measures (Bener et al., 2016; Bener et al., 2018; Dilshad et al., 2017; Islam & Hossin, 2016; Khan et al., 2017; Koca & Berk,

2018; Lam et al., 2009; Park, 2014; Tabatabaee et al., 2018; Yeh et al., 2012).

No study assessed the impact of physical fitness on internet addiction. No study used objective measures of physical activity, exercise or sport participation.

All of the admissible studies used valid and reliable internet addiction assessment tools.

Nineteen studies were performed in student population (school, college, university) except one study (Sahin & Lok, 2018) that selected the sample from general population.

Three studies were conducted in Turkey; two studies were performed in each of the five countries including Korea, Bangladesh, Qatar, Taiwan, and Iran.

In addition, one study was conducted in each country that includes Pakistan, USA, Europe, India, China, Vietnam, and Greece, respectively.

The included studies were varying with respect to outcome measures, measurements tools of physical activity and sports participation, samples size and characteristics, and data analysis.

The included studies were heterogonous in nature, therefore, a meta-analysis approach was considered in appropriate. So, the qualitative synthesis approach was used for this review.

Cross-sectional Studies included in the review (N = 19)								
Study	country	sample	Male %	Resp. rate (%)	PA	IA	Analysis	Results/ findings
Park, (2014)	South Korea	Nationwide internet survey study, stratified multistage cluster sampling design , Total sample was 74,980, middle and high school students, final sample consisted of 73,238 students with mean age of 15.06 ± 1.75 years Ranged from 12–18 years.	52.41	97.7	BMI, PA 7 days (2 items)	KS scale	Logistic regression, Sobel test	The findings suggested that greater level physical activity was significantly associated with lower score on internet addiction measure (AOR = 0.78; 95% CI = 0.73, 0.82), less perceived stress (AOR = 0.89; 95% CI = 0.86, 0.93) but greater sleep satisfaction (AOR = 1.13; 95% CI = 1.08, 1.18). In addition, an inverse relationship was appeared between physical activity and internet addiction moderated by low level of stress and higher level of sleep satisfaction (Z = −4.315, p < 0.001). More importantly, decreased stress was predicted by physical activity (B = −0.17; 95% CI = −0.19, −0.16; P < 0.001) that further decreased internet addiction (B = 1.38; 95% CI = 1.29, 1.45; P < 0.001).
Khan, et, al., (2017)	Pakistan	convenience sampling, sample size was 322 participants those finally responded out	54.3	85	Daily PA for one hour like walking, running and playing spe-	YIAT	Independent samples t-test, Multiple	The IA score was significantly lower (mean= 36.38±11.76)in participants engaged in regular physical activity/sports in comparison with IA score (mean=

		of 350 medical students, sample mean age = 19.27±1.01 years			cific sports.		linear Regression, Chi Square test,	40.37±15.05)of the participants with no activity.
Karamitsa, et, al., (2015)	Greece	Random sampling, Total sample was 863 junior and senior school students whereas final sample was 654, Mean age (14.93, SD = 1.48 yrs) Ranged from 13 to 19 years	52.90	76	PAQ- A	CIAS	MANOVA, Independent samples t-test, Chi square, Pearson correlation coefficient, Canonical Correlation Coefficient-CCC	Findings showed association of internet addiction with extended internet use, lower level of physical activity and higher level of depression (Y = - 0.827 + 0.324*Xhours - 0.039*XDepr +0.343*XPA).
Ting, et al., (2018)	Taiwan	Purposive sampling, University students, Study A: Total sample 346 and final sample was 339, Study B: total sample 346 and final sample was 333. Age 18-22 years	Study A: 68.43 Study B: 69.96	Study A: 97.97 Study B: 96.24	SH 2 items, modified SII	CIUS	Confirmatory factor analysis, Pearson's correlation, Structural equation modeling	1. Score of compulsive internet use scale was significantly negatively correlated with interests in sports participation and in physical education. 2. Sport habits linked to interests in mastering sports, insports participation, in watching sports, and interest in physical educations mediateto compulsive internet use scale and weekly exercise.

Park, et al. (2016)	South Korea	Convenience sampling, 388 middle and high school students, final sample345, Ages were 15-18 years	17.7	88.9	PA 7 days, Sport participation 3-itmed questionnaire	Korean scale for IA	Structural Equation Modeling, Confirmatory factor analysis, One-way analysis of variance Independent t-test	1. PA significantly increased the self-control (β ¼ .154, p< .05) and self-control consequently influenced the IA (β ¼_.142,p < .05). 2. Sports participation mediated by self-control significantly influenced IA(β ¼_.022, p < .01).
Bener, et al., (2018)	Turkey	multi-stage stratified random sampling, Total sample was 3000 Turkish Student and final sample was 2350, ages 18 to 25 years	43.14	78.3	PA 3 Self-developed questions.	IAT	Descriptive statistics, Multivariate and factorial analyses, Mann-Whitney test, Chi-square and Fisher's exact tests, Multiple regression analysis	Physical activity was significantly higher in non-addicted participants compared with internet-addicted participants (p value < 0.001).

Yeh, et al., (2012)	Taiwan	random sampling, of 708 freshmen final sample was 540, age adolescents	66.7	76.22	5-itemed PA change scale.	LC-PIU	Confirmatory factor analysis, Exploratory factor analysis, Pearson correlation,	Findings showed a significant negative association between IA and PA.
Bener, et al., (2013)	Qatar	Population university students, multistage stratified random sampling technique, Total sample 3000, final sample 2298, aged between 12 and 25 years,	71.6	76.6	Mild, moderate, and vigorous PA 3 itmes Self-developed questionnaire regarding lifestyle habits including physical activity and exercise	Young's IAT	Student t test, χ2and Fisher exacttests (2-tailed), Mann-Whitney U test, Spearman rank correlation coefficient, Multivariable logistic regression analysis,	1. Participants with problematic internet use (PIU) exhibited significantly lower level of moderate physical activity in comparison with non-PIU participants (47.8% vs 55.7%; P =0.005). 2. Multivariable logistic regression analysis yielded that those participants reported participation in moderate physical activities exhibited significantly lower odds of problematic internet use (OR = 0.73, 95% CI, 0.58-0.92; and OR = 0.77, 95% CI, 0.64-0.92).
Afrin, et al. (2017)	Bangladesh	Convenience sampling, Total sample 350 and final sample was 279 secondary school students, aged 14 - 17 years, mean age 15.63 years	42.29	79.71	2 items concerning playing game outdoor and physical exercise in yes/ no format.	OIAS	Chi-square test, multivariate logistic regression model	1. The multivariable logistic regression mode depicted that participants showed regular involvement in outdoor sports activities had 44 % less likely to experience addiction to internet in comparison with participants reported no sports participation

								(OR=0.56).
Sulania, A., (2016)	India	Purposive sampling, descriptive study, medical students, sample 250 and final sample 202, mean age was 20.3 ± 1.4 years	32.00	81	1-itemed Vigorous physical activity for 30min/day	Young's IAT	Logistic regression analysis, Chi-square analysis	Physical activity was not related with internet addiction.
Bener, A., et., al., (2016)	Qatar	schematic sampling procedure, Total sample 1624 and final sample was 1189, participants age 12-18 years, secondary school students	50.12	73.21	2-itemed Self-reported Sport participation And physical activity as extracurricular activities.	Youg,s IAT	Student-t test, Chi-square and Fisher's exact tests (two-tailed), Unpaired student's t test, multivariate linear regression model	Normal participants and internet addicted participates were not significantly different with respect to sport participation and physical activity level.
Durkee, et, al., (2016)	Europe	Random sampling, school-based adolescents, sample size=	43.4	96.25	PA2 items One hour during the past	YDQ	two-sided z-test Generalized line-	Internet addiction was significantly related with low level of physical activity (OR = 1.39).

		11,931 mean age of 14.89, 0.87 year			two weeks and regular sports participation		ar mixed models, Regression model, Independent samples t-test, One-way ANOVA	
Dang, et al., (2018)	Vietnam	Online survey, Sample size= 589 Vietnamese adolescents and youths, Respondent-driven sampling technique (RDS), aged from 15 to 24	36.8	100	IPAQ-SF	Short-form IA test (s-IAT)	Chi-squared test and Mann-Whitney test Multivariate logistic regressions	There was no association between IA and PA.
Ayas, et al., (2013)	Iran	Random sampling, 4342 high school and pre-college students, Mean age = 16.6, SD 1.5 yrs.	49.5	96.5	Single item question concerning exercise behavior	Young's (IAS)	Chi-square test and Univariate and multivariable logistic regression models	Non exercising students had highest rate of internet addiction (31% vs. 27%; P<0.001), andthey had significantly more likeliness of internet addiction than those who had exercise (from minimal to professional) (14 (4.2%) vs. 41 (1%), respectively; P<0.001).
Sahin, et al., (2018)	Turkey	Face-to-face interview, Universal sampling method, participants 100, Mean age was 28.27	64.8	100	IPAQ-SF (Turkish version)	YIBT-KF	Pearson's correlation analysis	The findings showed a moderate and negative association between PA and internet dependency (p<0.05).

Koca, et al., (2018)	Turkey	Convenience sampling, 1291 adolescents, Mean age= 16.2 years,	62.19	Not reported	Sport success and sport participation. (2 items, invalid tool)	Smartphone addiction scale	Kolmogorov-Smirnov test, Spearman's correlation, and chi-square test	Success in sports was significantly lower in internet addicted participants that that of non-internet addicts (p = 0.024).
Islam, et al., (2016)	Bangladesh	Population 37,000 university students, Stratified random sampling design, sample size 573, age 20-30 years (mean=25.1),	69.8	95.5	Single item moderate PA at least 10 min/day	PIU	Chi square test, binary logistic regression,	Physical activity level was significantly lower in no internet addicts in comparison with participants with internet addiction (20.0 vs 27.9%) (OR 0.84, 95% CI 0.58, 1.21).
Lam, et al., (2009)	China	Stratified random sampling, Sample size 1618, Age 13 to 18 years,	45.4	98.7	3 items asking regular, once or twice a week and not at all.	YIAS	Bivariate analyses, Logistic regression analyses,	Higher level of physical activity was related with lower level of internet addiction.
Tabatabaee, et al., (2018)	Iran	Random sampling, 928 students, Age 13 and 17 yr.	49	98.6	Self-developed 2 items of PA	YIAS	descriptive analysis and path analysiswith-Partial least square method, coefficient,	Internet addiction was associated with decreased physical activity; however, the effect size was medium.
Exploratory Qualitative Study								

Li, W, et al. (2015)	USA	Total sample 39, Final sample 27 university students, Age was 21 (SD = 3.6), ranging from 18 to 36	37.0	100	open-ended questions regarding exercise and sports participation	CIUS, YDQ	Correlation, Qualitative analysis of audiotaped sessions.	Failure to do exercise was reported as one of the negative consequences of IA

Abbreviations: PA, Physical activity; IA, Internet addiction; IAPSY, Internet Addiction Proneness Scale for Youth–Short Form (KS scale); YIAT, Young's Internet Addiction Test; CIAS, Chen internet addiction scale; PAQ- A, Physical activity questionnaire for adolescents ; CIUS, Compulsive internet use scale; SH, sports habits; SII, Sports Interest Inventory ; K-scale, Korean Scale for Internet Addiction Self-diagnosis; YDQ, Young's Diagnostic Questionnaire ; CIUS, Compulsive Internet Use Scale; IAT, Internet Addiction Test ;LC-PIU, Questionnaire of Lifestyle Change in Regard to Problematic Internet Use; OIAS, Orman,s internet survey; N/A, not applied; YDQ , Young's Diagnostic Questionnaire; GSHS, Global School-Based Student Health Survey; NR, not reported; PIU Pathological Internet Use; IPAQ-SF, International Physical Activity Questionnaire short form; IAS, Young's Internet Addiction Scale; YIBT-KF , Young's Internet Addiction Test Short Form- Turkish version;

Risk of bias

Of the twenty studies included in this review, four studies (three cross-sectional and one qualitative) were identified as very good quality studies (Bener & Bhugra, 2013; Bener et al., 2018; Li et al., 2015; Park, 2014).

The studies had low risk of bias due to having a representative samples, sufficient sample sizes, satisfactory response rate, low level of ascertainment bias, and used valid and reliable measurement tools and applied appropriate data analysis tests to examine relationship of physical activity with internet addiction.

Moreover, we identified seven studies with good quality having low risk of bias (Aikaterini T. Karamitsa & Emmanouil K.

Skordilis, 2015; Ayas & Horzum, 2013; A Bener et al., 2016; Durkee et al., 2016b; Islam & Hossin, 2016; Lam et al., 2009; Tabatabaee et al., 2018).

These studies had some limitations that include: 1) used invalid physical activity measure (5/7) (Ayas & Horzum, 2013; Durkee et al., 2016a), two (2/7) used small sample sizes (Islam & Hossin, 2016; Tabatabaee et al., 2018), and low level of response rate against the prescribed threshold (2/7) (Ayas & Horzum, 2013; A Bener et al., 2016).

However, all of these studies used systematic sampling approaches, used representative samples, used sufficient sample sizes (except two studies), minimized the ascertainment bias, used valid and reliable internet measures, controlled for the major confounders, and applied appropriate statistical tests for analysis.

Nine studies were found in fair category that had moderate risk of bias with some methodological weaknesses (Dang et al., 2018; Dilshad et al., 2017; Khan et al., 2017; Koca & Berk, 2018; Park et al., 2016; Sahin & Lok, 2018; Sulania et al., 2016; Ting et al., 2018; Yeh et al., 2012).

For example, these studies used small sample size (4/9) (Dilshad et al., 2017; Park et al., 2016; Sulania et al., 2016; Yeh et al., 2012)less representative samples (4/8) (Dang et al., 2018; Dilshad et al., 2017; Sahin & Lok, 2018), and less response rate than suggested threshold (3/8) (Bener et al., 2016; Koca & Berk, 2018; Ting et al., 2018).

However, these studies did: 1) controlled for major confounding factors, 2) used appropriate tests for analysis, 3) used valid and reliable internet addiction measures, and 4) minimized the ascertainment bias.

Summary of evidence

Three studies in our review had very low risk of bias. All of studies included in this category used systematic sampling to examine effect of physical activity on internet addiction in high school students or undergraduate students.

Among those studies, Park et al. (2017) involved 73238 partici-

pants from 400 middle and 400 high school students across the South Korea in the survey study. Participant's demographic information, body mass index and physical activity was measured using a valid and reliable measure consisting of 2 items based international physical activity questionnaire.

Internet addiction was measured through Korean version of internet addiction proneness scale for youth. The sleep quality and perceived stress was also measured by single item questions.

The findings suggested that greater level physical activity was significantly associated with lower score on internet addiction measure (AOR = 0.78; 95% CI = 0.73, 0.82), less perceived stress (AOR = 0.89; 95% CI = 0.86, 0.93) but greater sleep satisfaction (AOR = 1.13; 95% CI = 1.08, 1.18).

In addition, inverse relationship was found between physical activity and internet addiction moderated by low level of stress and higher level of sleep satisfaction ($Z = -4.315$, $p < 0.001$). More importantly, decreased stress was predicted by physical activity (B = −0.17; 95% CI = −0.19, −0.16; p< 0.001) that further decreased internet addiction (B = 1.38; 95% CI = 1.29, 1.45; p< 0.001).

In another study with very low risk of bias conducted by Abdulbari Bener et al. (2018) assessed relationship between physical activity and internet addiction involving university students in a randomly selected large sample.

The researchers used valid and reliable internet addiction measure and 3 items physical activity measure.

Other measures include demographic information, sleep, fatigue, physical problems and lifestyle habits. Findings showed a significant higher involvement of physical activity in non-internet addicts compared to those who have internet addiction and the vice versa (p value < 0.001).

Similarly, Abdulbari Bener and Bhugra (2013)examined effect of physical exercise in a randomly selected large sample of school and college students in Qatar.

The measures used in this study to examine physical activity, internet addiction, sleep and depression were valid and reliable. Results demonstrated that internet addicts had significantly lower level of moderate physical activity in comparison with non-internet addicts (47.8% vs 55.7%; p = 0.005) and significant lower odds of problematic internet use was reported in those who participated in moderate physical activities (OR = 0.73, 95% CI, 0.58-0.92; and OR = 0.77, 95% CI, 0.64-0.92).

On study in this review with very low risk of bias used exploratory qualitative approach to investigate characteristics of internet addicts (Li et al., 2015).

Findings of this study demonstrated that internet addicts was characterized by poor sleep, negative emotional states, low level of focus, and decreased physical activity.

The remaining seven studies with low risk of bias also showed inverse relationship between physical activity and internet addiction. Among these studies, Aikaterini T. Karamitsa and Emmanouil K. Skordilis (2015) selected medium size sample of high school students through random sampling approach using valid and reliable physical activity, internet addiction and depression measures.

Findings suggested that internet addiction was linked with higher internet use, higher depression levels and lower level of physical activity (Y = - 0.827 + 0.324* X hours - 0.039* X Depr+ 0.343*XPA).

Other studies with low risk of bias found that, internet addiction was associated with lower level of physical activity (OR = 1.39) (Durkee et al., 2016a), less physical activity was significantly related with higher internet addiction (31% vs. 27%; P<0.001) (Ayas & Horzum, 2013), significantly higher physical activity in non-internet addicts compared with internet addictions (20.0 vs 27.9%) (OR 0.84, 95% CI 0.58, 1.21) (Islam & Hossin, 2016), and inverse relation between internet addiction and physical activity (Lam et al., 2009; Tabatabaee et al., 2018).

However, one study in this category showed no significant association between physical ac-

tivity and internet addiction (Bener et al., 2016).

Among the remaining nine studies with moderate risk of bias, Park et al. (2016) assessed associations of sports participation with internet addiction in middle and high school students recruited through convenience sampling by administering valid and reliable physical activity, internet addiction and self-control measures.

The analysis of structural equation modeling proposed that self-control significantly affected by participation in physical activity (β ¼ .154, p < .05) and internet addiction significantly influenced by self-control (β ¼ _.142, p < .05). Additionally, internet addiction influenced by self-controlled physical activity (β ¼ = .022, p < .01).

Ting et al. (2018) used purposive sampling approach while assessing relation of physical activity with internet addiction by applying valid and reliable physical activity and internet addiction measures.

The analysis showed a negative relationship between internet addiction and interests in physical activity and sports participation.

Moreover, based on random sampling, valid and reliable internet addiction, depression and loneliness measures, the analysis of Yeh et al. (2012)'s study indicated that internet addiction and physical activity were negatively related.

Results from other studies in the fair category also demonstrated a significantly higher internet addiction in participants with no physical activity (p-value=0.01) (Khan et al., 2017), and those who participated in outdoor physical activity showed lower score on internet addiction (OR=0.56) (Dilshad et al., 2017), a negative correlation between physical activity and internet addiction, (p value < 0.05) (Sahin & Lok, 2018), and success in sports was significantly lower in internet addicted participants than that of non- internet addicts (p = 0.024) (Koca & Berk, 2018).

The remaining two studies with moderate risk of bias showed no association between internet addiction and physical

activity (Dang et al., 2018; Sulania et al., 2016).

In sum, analysis of this review yielded that out of twenty admissible studies, seventeen studies showed inverse relationship of physical activity with internet addiction whereas the remaining three studies indicated no relationship between both variables.

Notably, all of the four studies that classified as very good category demonstrated strong support for physical activity to reduce internet addiction.

One study with good quality and two studies in fair category found no effect of physical activity on internet addiction.

Discussions

This review sought to determine association of physical activity with internet addiction. We identified twenty studies that fulfill the inclusion criteria for this review.

Ten out of twenty studies identified as very good or good category showing result in the favor of inverse relationship between physical activity and internet addiction. While one study with good quality showed no relation between both variables (Bener et al., 2016).

Of the remaining nine studies with fair quality, findings of the seven studies corroborated negative association between physical activity and internet addiction.

However, of these, two studies showed no effect of physical activity on internet addiction (Dang et al., 2018; Sulania et al., 2016).

Seventeen studies (85 % studies) out of twenty studies showed inverse relation between physical activity and internet addiction. Notably, no study found positive relation between physical activity and internet addiction.

The findings from these studies collectively provide sufficient support to the view that physical activity can be an effective interventional strategy for prevention and treatment of internet addiction, whereas, three studies (15 %) failed to show any effect.

Another findings emerged from these results is that more

support was obtained in favor of inverse relation of physical activity with internet addiction from the studies used adolescent or emerging adult participants.

This led us to conclude that, physical activity may more effective to reduce internet addiction in adolescents and emerging adults.

However, findings emerged from these studies limits the generalizability due to following limitations.

1) All of the included studies used self-reported measures of physical activity instead of objective measures.

Data obtained through self-reported measures likely to expose of risk of bias due to social desirability. In addition, some studies also used invalid and unreliable physical activity measures.

Instead of self-reported measures, objective measures of physical activity considered more precise and accurate assessment procedure to track the level of physical activity.

2) Some studies used small sample, although the authors of those studies justified that sample size, however, studies with larger sample size have greater generalizability.

3) Some studies used convenience samplings that enhance the risk of bias. More studies with larger sample size can provide more strong evidence with respect to effect of physical activity on internet addiction.

4) Findings emerged from this review primarily based on cross-sectional studies that provide week evidence.

Absence of the findings from cohort studies, longitudinal studies, randomized controlled studies, and experimental studies in support of efficacy of physical activity for reduction in internet addiction raises the question regarding strength of the evidence for the present findings.

5) Evidence from the studies assessed relationship of physical fitness and sedentary behavior are absent in the present review.

Findings from the studies determining associations of partici-

pants various physical fitness and severity of sedentary behavior with internet addiction may provide more clear picture about the phenomenon that can contribute more detailed understanding regarding factors of internet addiction.

6) Findings concerning appropriate mode and level of physical activity that foster more promising effects on internet addiction also missing. This limits to draw any conclusion that what type and amount of physical activity for what ages of people to see the beneficial effects of physical activity for reduction in internet addiction.

7) All of the included studies were chosen from publication in English language. This limitation suggests considering studies published in other languages for obtaining confidence on the present findings.

Therefore, keeping in view these methodological limitations, more cohort and cross-sectional studies using rigorous methodologies are suggested to corroborate findings emerged from the present review.

However, in general, findings of this review are congruent with other studied assessed relationship of physical activity with various addictive behaviors.

For example, a meta-analysis conducted by Wang, Wang, Wang, Li, and Zhou (2014) evaluated the effectiveness of physical activity for prevention and treatment of addictive behavior concerning substance use.

Based on the data analysis obtained through twenty-two studies, findings indicated that aerobic exercise with moderate and high intensity can potentially reduce addictive behavior towards substance abuse.

Moreover, a recent review conducted by Li, Pursey, Duncan, and Burrows (2018) examined relation of physical activity with addictive behavior related to eating. Findings suggested that food related addictive behavior was associated with sleep and physical activity.

Depression is widely reported as co-morbid psychiatric condition in individuals with internet addiction.

In line with findings of this review, a recent review of randomized control studies conducted by Bailey, Hetrick, Rosenbaum, Purcell, and Parker (2018) suggested that physical activity has the potential to use as intervention to reduce depression in adolescents and adults.

These findings lead us to assume that physical activity may reduce negative psychological conditions accompanied by internet addiction that further reduce internet addiction.

In this review, two studies provided some indication concerning psychological variables that likely to account for the internet reducing effect of physical activity.

For example, analysis of the study of Park et al. (2017) showed that physical activity significantly reduced stress and internet addiction, and improved sleep.

Findings further indicated that physical activity resulted in reduction in stress and reduced stress further significantly reduced internet addiction. Similarly, physical activity associated with significantly increased self-control, and self-control significantly decreased internet addiction (Park et al., 2016).

Moreover, Cao and Chi (2016) indicated that regular participation in physical and sports activities enhances social support that further contributes to reduce internet addiction.

These findings collectively proposed that physical activity reduces stress, and increases sleep quality, self-control, and social support that possibly work as underlying mechanisms to reduce internet addiction.

Conclusion

It is concluded that, based on findings from this review, physical activity can be suggested to use as intervention to prevent and reduce internet addiction among adolescents and emerging adults.

Psychosocial factors including increased self-control, social support, sleep quality, and reduced stress might account for the positive effects of physical activity on internet addiction.

However, absence of findings from studies with strong meth-

odology (i.e., longitudinal, cohort, intervention studies with randomized control trials) and absence of studies with objective physical activity measures, weaken the interpretations emerged from this review.

Further studies that overcome these limitations are required to confirm these findings.

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