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Abstract

Researchers worldwide have developed and validated several scales to assess various forms of adults' digital addiction. The urge for some of these scales found support in the World Health Organization's inclusion of gaming disorder as a mental health condition in its eleventh revision of the International Classification of Diseases in June 2018. Additionally, several studies have shown that children are starting to use digital devices (e.g., tablets, smartphones) at a very young age including playing video games and engaging in social media. Consequently, the need for early detection of the risk of digital addiction among children is becoming more of a necessity. In the present study, the Digital Addiction Scale for Children (DASC) – a 25-item self-report instrument – was developed and validated to assess the behavior of children 9 to12 years old in association with digital devices usage including video gaming, social media, and texting. The sample comprised 822 participants (54.2% males), from Grade 4 to Grade 7. The DASC showed excellent internal consistency reliability ($\alpha = .936$) and adequate concurrent and criterion-related validities. The results of the confirmatory factor analysis showed that the DASC fitted the data very well. The DASC paves the way to (i) help the early identification of children at risk of problematic use of digital devices and/or becoming addicted to digital devices, and (ii) stimulate further research concerning children from different cultural and contextual settings.

INTRODUCTION

Scientific research investigating digital addiction in its different forms among children is still in its relative infancy. Digital devices such as laptops, tablets, smartphones, and game consoles have become an integral part of most households and their use among children has been on the rise and can begin at a very young age. They provide access to highly entertaining activities, are easy and convenient to use, affordable to most, portable, and interactive.[1] Children use these devices to play videogames, to watch videos (e.g., on *YouTube, Twitch*), to communicate, and to interact in social media (e.g., *Instagram, Snapchat, Facebook, WhatsApp*). Although most users perceive their devices as positive in their lives, their excessive use or misuse among a minority may become problematic and bring about some risks negatively affecting their educational, psychological, social, and physical wellbeing.[2-6] In June 2018, the World Health Organization (WHO) included gaming disorder as a mental health condition in its eleventh edition of the International Classification of Diseases (ICD-11).[7] The ICD-11 states that gaming disorder is "characterized by a pattern of persistent or recurrent gaming behaviour that extends over at least 12 months." Gamers with this disorder have little or no control over gaming, give gaming precedence over other life interests and daily activities, and continue gaming despite its negative consequences on them.[7] This was preceded by the inclusion of Internet Gaming Disorder (IGD) in the most recent (fifth) edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) as a condition for further studies along with nine proposed criteria used to assess IGD.[8] The long-term recurrent nature of this disorder is not limited to mental distress and impairment, but can also extend to family, social, educational, and occupational aspects of life.

In modern society, playing videogames and the use of social media are reinforcing and complement each other. For instance, at the time of writing, *Fortnite* (a *Battle Royale* genre game) which is one of the most popular videogames among preteens and teens today, with 200 million users worldwide,[9] is being widely played even among children,[10] and *Apex Legends* (also a *Battle Royale* game) reached 50 million players in just one month after its release in February 2019. In addition to playing the game, 80% of *Battle Royale* players watch professional *Battle Royale* players playing the game on *YouTube* and *Twitch* via live streaming[10] and participating in its related social media platforms and channels. Accordingly, players may be constantly switching back and forth among their different technological devices to both play and watch such games.

A CommonSense Media survey of American students reported that approximately three-quarters of teenagers own a smartphone, and 24% of adolescents describe themselves as "constantly connected" to the Internet.[11] A study by the Center of Addiction and Mental Health[12] surveyed 11,438 Grade 7 to Grade 12 students from Ontario (Canada). They reported that (i) 20% spent five hours or more on social media daily, compared to 16% in 2015 and 11% in 2013, (ii) 23% played videogames daily or almost daily, (iii) 9% played videogames for five hours or more per day, (iv) 30% of secondary school students spent five hours or more per day on electronic devices (smartphones, tablets, laptops, computers, gaming consoles) recreationally, and (vi) 5% of secondary school students reported symptoms that may suggest a serious problem with technology use. Also, research shows that some pre-teens also engage in excessive use of digital devices, and that a small minority may experience symptoms of behavioural addiction.[13]

The widespread and potentially problematic use of technology necessitates the development of a scale to assess children's behaviours concerning their use of digital devices. While several scales related to different types of digital addiction have been developed, they mainly target populations of over 12 years of age and specialize in one aspect of technology such as IGD,[14] social media addiction[15] and smartphone addiction.[16] To the authors' knowledge, and based on extensive search using all major academic research databases, only one scale was found that was developed for children under the age of 12 years old and that specifically addressed videogame addiction only.[13]

The aim of the present study was to develop and validate an instrument to assess children's overall addiction to digital devices. As several studies have associated digital addictions with ADHD and OCD,[6, 17] stress,[18-20] anxiety, depression, and narcissism,[5, 21] low self-esteem,[5, 22, 23] and poor academic performance,[2, 24-26] a scale for assessing dependency to digital devices will help in the assessment and consequently the diagnosis and treatment of the different symptoms among children aged 9-12 years old.

METHOD

Participants

In the present study, students from Grade 4 to Grade 7 constituted the target population. Fifteen schools were selected by simple random sampling technique, from regions geographically distributed across Lebanon. The sample comprised 822 participants (54.2% males) with ages ranging from 9 to 12 years (M_{age} = 10.99 years, SD = 1.26 years).

Measures

The study comprised a short survey consisting of two separate sections, including one for demographic information and another for the Digital Addiction Scale for Children (DASC). The demographic information section collected age, gender, most recent grade average at school, and digital device usage habits including types of digital devices used, purpose of using digital devices, average number of hours of digital device usage.

Development of the Digital Addiction Scale for Children: The DASC is a 25-item self-report instrument that was developed based on the nine diagnostic criteria proposed in the DSM-5 for IGD and also mapped onto Griffiths'[27] six core addiction criteria in the components model of addiction (preoccupation, tolerance, withdrawal, deception, mood modification, displacement, conflict, problems, and relapse). Added to those were the three additional criteria (i.e., problems, deception, and displacement). The problems criterion was included because it refers to life necessities that could become uncontrollable due to digital addiction such as sleep, discord with parents, money management, and academic achievement. Deception referred to how children to lie to their parents about the amount of time they spend using their digital devices and about what they do on their devices. Displacement refers to the situation when parents feel disconnected from their children and results in the compromising of the family unit.

The authors adopted all the criteria and progressed towards discriminant validity to demonstrate that they are actually unrelated. Indeed, discriminant validity was established because the nine criteria were not highly correlated among each other (Table 1). Although there is no standard value for discriminant validity, because all correlations were less than .7 (ranging between .389 and .696), this could imply that the criteria are related but not redundant. Consequently, discriminant validity most likely exists among all criteria, and as they are assessing different constructs.

The items were created based on the theoretical definition of each addiction criterion assuming that addiction is a human trait that is not confined to a particular age group. During the pilot phase, the authors created an initial set of items for each addiction criterion guided by the criterion's theoretical definitions, the understanding of digital addiction, and a thorough investigation of relevant literature. The initial pool included a substantial number of items with the aim of sampling all possible and known alternatives, language simplicity, items' straightforwardness, and appropriateness to children's reading level. This initial pool of items was reviewed by knowledgeable experts in the field with special focus on content validity. The experts provided suggestions for adding, removing, and amending items. Also, the items were subjected to content analysis by educators associated with the target population. Items were accepted, rejected, or amended based on the majority of opinions.

Two major factors led to deciding on the number of items per addiction criterion. Some criteria encompassed a smaller set of items to start with because by definition they represented narrower content and consequently resulted in a fewer number of items. The second major factor was that given that there are no known specific rules about the number of items to retain for each criterion, the authors developed their own strategy to guide our decision on the retention of a necessary and sufficient number of items per addiction criterion. To start with, many more items were generated than would be needed for the final scale. Following this, the authors:

(i) Retained an adequate parsimonious number of items that had satisfactory conceptual consistency with each other on the addiction criterion being assessed;

(ii) Deleted items that had the lowest criterion loadings;

(iii) Deleted items that had the highest cross-loadings;

(iv) Eliminated items that did not correlate strongly with the scale score that excluded that item;

(v) Deleted items that contributed the least to the internal consistency of DASC scores;

(vi) Retained the item that used simple language, straightforward, and appropriate for the reading level of children.

Once the scale had been developed, it was pre-tested for the content adequacy of the items. The item selection followed an iterative process involving several periods of item writing and rewriting, implementing conceptual and psychometric analysis at each iteration to ensure that each addiction criterion-specific set of items was relevant and representative to the criterion under focus. Two children English language teachers, professionals in scale development, and a child psychologist reviewed the questions and made sure that they are appropriate for the target population. Sample questions include: *"When I am not at school, I spend a lot of time using my device"* (preoccupation), and *"I have spent more and more time on my device"* (tolerance). All items are rated on a five-point Likert scale using: 1 ("Never"), 2 ("Rarely"), 3 ("Sometimes"), 4 ("Often"), and 5 ("Always"). Scores range from 25 to 125, with higher scores indicating a higher digital dependency level.

Procedure

The selected schools were contacted for securing prior permission from their administrations for data collection. The survey was emailed along with a cover page that included an explanation of the nature and purpose of the study, and a list of instructions on how the survey will be administered. All schools opted to obtain students' parents consent for their child's participation through their own internal routine. Upon schools' and parents/guardians' consent forms approval, dates and times were scheduled. Before its distribution, a trained assistant researcher explained the procedure of filling the survey to all participants who assured them of confidentiality and anonymity.

Statistical analysis

Given that the DASC has 25 items, the present study required at least 500 respondents for robust analytical purposes. The present study's sample size was 822 and therefore exceeded the minimum number of participants needed. The Statistical Package for the Social Sciences, version 24.0 for Windows (SPSS Inc., Chicago, IL), and AMOS were used to conduct statistical analysis. The analysis provided (i) descriptive data for the DASC, (ii) internal consistency (Cronbach's α), (iii) dimensionality and factorial validity, (iv) criterion-related validity, and (v) a confirmatory factor analysis. The confirmatory factor analysis (CFA) was executed using a structural equation modelling (SEM) with IBM SPSS Amos Graphics 24.0 in order to test the structure underlying the 25 items of the DASC. The latent construct was digital addiction, which was not directly observed and was considered the endogenous variable. The 25 items were considered the exogenous variables used to assess the participants' digital dependency level.

RESULTS

The main purposes of obtaining descriptive statistics were to study the scale's items, and to secure evidence of the existing situation and current conditions. Indeed, Table 2 shows the means, standard deviations, corrected-item total correlation, and loadings for each of the 25 DASC items. Most items were skewed toward the less frequent tail of the distribution and demonstrated adequate variability. More than 25% of the items had averages that ranged between 'never' (value of 1) and 'rarely' (value of 2). The item that had the highest mean was *"When I am not at school, I spend a lot of time using my device"* (M=3.36). The item that encompassed the highest rating (22.3%) for 'always' was *"Using my device helps me to forget my problems."*

A criterion was considered met if at least one of its items was answered with 'strongly agree'. Less than half of the participants (45.4%; 46.1% males) fulfilled none of the DSM-5 nine criteria (Table 3). A total of 42.2% participants (59.9% males) met one to four criteria, and 12.4% (61.8% males) met five or more criteria. It is noteworthy, that the prevalence of criteria fulfilment among participants followed this order: mood modification (31.6%), preoccupation (28.7%), withdrawal (26.9%), problems (18.5%), relapse (16.2%), conflict (15.1), displacement (14.1%), tolerance (13.7%), and deception (4.4%).

Participants spent a mean daily average of 2.14 hours a day on their digital device during weekdays (SD=2.41 hrs), and 5.87 hours a day at weekends (SD=5.44 hrs). Of all participants, 14.4% (65.2% males) reported not using their digital devices during weekdays, compared to 0.9% (71.4% males) not using their digital devices on weekends. Of all participants, 69.8% (53.1% males) used their digital devices two hours or less on weekdays, compared to 28.3% (42.8% males) on weekends. Table 4 shows that children as young as nine years old were using a mobile phone. Also, of the nine-year old students, more than two-thirds reported using a mobile phone (67.7%). At 12 years, approximately 90% of participants reported using a mobile phone.

Gender differences

An independent-samples *t*-test was conducted to compare the DASC scores for males and females. There was a significant difference in scores for males ($M = 59.1$, $SD = 19.6$) and females ($M = 53.5$, $SD = 18.9$; $t\ (815) = 4.1$, $p<.005$, two-tailed). The magnitude of the difference in the means (mean difference = 5.7, 95% CI: 2.9 to 8.2) was small (ETA squared = .02). The mean DASC score of males was higher than that of females. It is noteworthy that one standard deviation above the mean score of females (72.4) barely exceeded (1.4) the cut-off of DASC (71.0), while that of males (78.7) exceeded it by 7.7, which indicates that males were at higher risk of becoming addicted to digital devices. The independent-samples *t*-test that was conducted to compare the DASC scores for addict males and females showed that there was no significant difference in scores for males (M = 84.3, SD = 12.1) and females (M = 85.6, SD = 11.8; t (189) = -.7, p=.475, two-tailed). The magnitude of the differences in the means (mean difference = -1.3, 95% CI: -4.9 to 2.3) was minimal (ETA squared = .003). All the results are shown in Table 5.

Gender-based correlations were calculated between the DASC and other research variables. The weekday and weekend gameplay time of both males and females had statistically significant and positive medium correlation with DASC score (Table 5). It is noteworthy that within the addict cohort, both males and females' weekends gameplay time did not correlate with DASC, although the average weekends' gameplay time of males was 10.4 hours, and that of females was 8.1 hours (Table 5). Gender-based correlations were calculated between age and other research variables. The DASC score of both males and females in the 'addict' group did not correlate with age (Table 7). Also, the weekday and weekend gameplay time of both males and females did not correlate with DASC score (Table 7).

Internal consistency

The data collected for the DASC produced excellent internal consistency reliability with Cronbach's alpha being very high (.936). The computed α showed that the index of measurement error in the DASC was very small (0.116).

Dimensionality and factorial validity analysis

The exploratory principal component analysis to examine the dimensionality of DASC was performed using SPSS version 24, beginning with reliability analysis. The Inter-Item Correlation Matrix contained no negative values, indicating that the items were assessing the same characteristic. The Corrected Item-Total Correlation values were all positively associated with the total score and ranged from 0.415, Item 16, to 0.731, Items 12 and 21 (Table 2). This indicates that items in the scale were assessing the same construct. None of the loadings (Table 2) were considered poor. In addition, none of the values in the column headed "Alpha if Item Deleted" were higher than 0.936, indicative of the DASC's homogeneity, suggesting that no item should be removed from the DASC.

Next, the 25 items of the DASC were subjected to the principal components analysis (PCA) extraction method. The rotation method was Oblimin with Kaiser Normalization. Prior to performing PCA, the suitability of the data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of 0.3 and above (77.05%). The Kaiser-Meyer-Olkin measure of sampling adequacy (MSA) was 0.960, which exceeded the recommended value of 0.600, and Bartlett's Test of Sphericity reached statistical significance (chi-squared = 8732.443, df=300, $p<.0005$), supporting the factorability of the correlation matrix. In fact, PCA demonstrated the presence of two components with eigenvalues exceeding 1, explaining 40.63%, and 5.69% of the variance, respectively. An inspection of the scree plot showed a clear break after the first component. Hence, based on Catell's scree test, one component should be retained. However, the results of the parallel analysis showed two components with an eigenvalue (10.159 and 1.421, respectively) exceeding the corresponding criterion value (1.331 ± 0.029 and 1.279 ± 0.024, respectively) for a randomly generated data matrix of the same size (25 variables x 828 participants). This was further supported by Velicer's minimum average partial (MAP) test that was implemented on the correlation matrix using the principal components extraction method. The MAP suggested a two-factor solution. There were slight variations in the individual factor loadings between PCA and MAP.

Furthermore, the component correlation Matrix indicated that the relationship between the two factors was strong (-.559). Thus, it was appropriate to use the Oblimin rotation solution which is an oblique rotation used when factors are assumed to be correlated[28]. The Oblimin rotation provided the pattern matrix (Table 8). Thirteen items loaded on Component 1 including the complete item sets of conflict, displacement, and problems criteria. Looking at the items pertaining to Component 1, especially those with the highest loadings and the respective criteria they represent, it was labelled “Interpersonal Factors”. Most items pertaining to this factor expressed consequences relating to relationships or communication between people. Twelve items loaded on Component 2 including the complete item sets of mood modification, withdrawal, and tolerance criteria. Looking at the items of Component 2 especially the ones with the highest loadings and the respective criteria they represent, it was labelled “Intrapersonal Factors”. Most items pertaining to this factor expressed consequences taking place or existing in the mind. The preoccupation and relapse criteria had their items split between the two components. The pattern matrix is supported by the structure matrix (Table 9) which shows the correlations between the 25 scale items and the ‘Interpersonal’ and ‘Intrapersonal’ factors.

Concurrent validity analysis

Concurrent validity was investigated by examining the bootstrapped Pearson’s correlation coefficient with 10,000 bootstrap samples and 95% BCa CI between the total scores and the item “*Choose the option that best describes your addiction to using your devices*”, which yielded adequate results ($r=0.61$, $R^2=0.37$, $p<.0001$, 95% BCa CI [0.56–0.66]), supporting the concurrent validity of the scale.

Criterion-related validity analysis

Criterion-related validity was confirmed by the statistically significant and positively medium correlation between the DASC and both the weekdays’ gameplay time ($r=.385$, $p<.0005$, 95% CI [.318, .446]), and the weekends’ gameplay time ($r=.454$, $p<.0005$, 95% CI ([.399, .513]).

Several studies adopted the positive correlations between different digital addiction scales and gameplay time as a criterion-related validity test. Examples include the IGD-20 Test,[14] the Video Game Dependency Scale,[29] and the French and German validation of the Game Addiction Scale (GAS).[30] Moreover, there was a statistically significant and positively strong correlation between the DASC and the self-reported digital addiction (r=.612, p<.0005, 95% CI [.564, .653]), and the participants' description of their parents' digital addiction (r=.173, p<.0005, 95% CI [.096, .248]).

Confirmatory factor analysis

The χ^2 to df ratio was 2.434 (p<0.00005) (Table 10) which indicated that the model was an adequate fit.[31] The Root Mean Square Error of Approximation (RMSEA) was 0.0418 which indicated a good model fit because it was less than 0.050. Since the computed PCLOSE (0.994), which tests the null hypothesis that RMSEA is no greater than 0.05, was significantly greater than 0.05, there was no evidence to reject the null hypothesis. Additionally, the normed fix index (NFI), the comparative fix index (CFI), and the Tucker-Lewis coefficient (TLI) were 0.933, 0.959, and 0.951, respectively, and suggested that the model fitted very well. The SRMR (the standardized RMR, root mean square residual), which was 0.0337, indicating a very good fit because it was less than 0.05.

DISCUSSION

The aim of the present study was to develop and validate a psychometric scale to assess digital addiction among children aged 9 to 12 years old. The DASC was developed using the theoretical framework built upon the nine DSM-5 criteria for IGD[8] and the components model of addiction.[27] To achieve the study's aim, the DASC underwent rigorous psychometric examination. The results supported the internal consistency of DASC as assessed by Cronbach's alpha, and corrected item-total correlation.

Based on a recommendation of meeting five or more of the DSM-5's nine criteria, 12.4% were identified as at risk of addiction to digital devices (14.2% males and 10.2% females; Table 3), and within the cohort of 'addicts', 62.4% were males. The order of 'mood modification' followed by 'preoccupation' as the most and second to the most endorsed criteria (31.6% and 28.7% respectively), similar to the findings of a German study[29] although not to the same intensity. Almost one-third of the sample used digital devices for mood modification, and more than one-quarter of the sample was preoccupied with digital devices.

The exploratory principal component analysis showed that all items assessed the same construct and that the scale was homogenous. In terms of factor analysis of the DASC, the results demonstrated a two-factor structure. The analysis of both concurrent and criterion validity also yielded good results that further highlighted the concurrent and criterion validity of the new scale. Additionally, the results of the confirmatory factor analysis provided adequate results regarding the construct validity of the DASC.

Future studies can further expand on the findings of the present study by using the DASC in different samples and cultural contexts. The DASC appears promising but still requires further testing using a clinical sample. Although the present study provided robust findings in relation to the rigorous psychometric testing, it is not without its limitations. Although most scales that have been developed in the field use self-report questionnaires, their associated possible biases should be mentioned, such as short-term memory recall bias and social desirability biases (although the latter is likely to be less pronounced in children). Also, the criterion-related validation was carried out by correlating the DASC with time spent using digital devices. Finally, other criteria should be considered in future studies of the DASC, such as correlation with other digital addictions, and different psychiatric disorders.

CONCLUSION

The present study investigated the psychometric properties of the DASC. First, the reliability analysis showed that its internal consistency was excellent. Consequently, the study showed that the DASC is a valid and reliable instrument for use with children ranging between 9 to 12 years old. The main value of this study is that it conceptualized children's addiction to digital devices paving the way to (i) help clinically identify children at risk of digital addiction and (ii) stimulate further research concerning children from different cultural and contextual settings. The DASC may prove to be a psychometrically robust tool to assess addiction to digital devices including online applications used on them. In future investigations, researchers can collaborate and compare results in cross-cultural research settings. Having established the DASC psychometrically, the instrument may pave the way for establishing prevention programs and investigating treatment plans using clinical samples.

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