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THE EFFECT OF TRIUMF MOBILE HEALTH GAME ON PSYCHOLOGICAL WELL-BEING AND HEALTH-RELATED QUALITY OF LIFE AMONG PEDIATRIC CANCER PATIENTS: A PILOT STUDY

Master's thesis

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The effect of Triumf mobile health game on psychological well-being and health-related quality of life among pediatric cancer patients: A pilot study

Abstract

Children with chronic illness hold a higher risk of developing mental disorders, and psychological support may not be available to all patients. Triumf mobile solution is a gamified digital health intervention, which aims to detect, prevent and/or reduce the potential psychological problems resulting from chronic illness. The current study described the theoretical basis of Triumf intervention game and investigated the within-person effect of the intervention on psychological well-being and health-related quality of life (HRQoL). Nine pediatric cancer patients aged 7-12 years participated in a 60-day intervention period with a suggested daily gameplay of ten minutes. Participants and their parents filled in Strengths and Difficulties Questionnaire (SDQ) and KIDSCREEN-52 (KS-52) before and after the intervention. Questionnaire scores were compared with in-game reported well-being, motivation and attitude scores, and intervention activity. Psychological well-being of the participants improved after the intervention period. KS-52 physical health subscale score was observed as a broad approximate instead of generic HRQoL, which also improved after the intervention period. Motivation and attitudes were not associated with participants' well-being, HRQoL or intervention activity. The hypothesis that the intervention questions could detect similar problems as questionnaires found partial support. The results suggest that Triumf digital intervention in the form of a mobile health game could have a positive effect on the psychological well-being among pediatric cancer patient population. Future studies should seek to primarily address the intervention's effect among other populations, and further validate the questions used in the intervention.

Keywords: digital health intervention; mobile health platform; mHealth; serious game; game for health; health app; psychological support; mental health; chronic illness; cancer; pediatrics

Triumfi mobiilse tervisemängu mõju lapseea vähipatsientide psühholoogilisele heaolule ja tervisega seotud elukvaliteedile: esmauuring

Kokkuvõte

Krooniliste haigustega lastel on kõrgendatud risk vaimsete häirete tekkeks ning vajalik psühholoogiline tugi ei pruugi olla patsientidele kättesaadav. Mobiilimäng ja sekkumine Triumf on mängustatud digitaalne terviselahendus, mille eesmärk on tuvastada, ennetada ja/või vähendada krooniliste haigustega kaasuvaid psühholoogilisi probleeme. Käesoleva uuringu eesmärk on kirjeldada Triumfi sekkumise teoreetilisi aluseid ning uurida sekkumise indiviidi-sisest mõju psühholoogilisele heaolule ja tervisega seotud elukvaliteedile. Üheksa lapseea vähi patsienti vanuses 7-12 aastat osales 60 päeva pikkuses sekkumises soovitusliku päevase mänguajaga kümme minutit. Osalejad ja nende vanemad täitsid enne ja pärast sekkumist Tugevuste ja Raskuste Küsimustiku (TRK) ning KIDSCREEN-52 (KS-52). Küsimustike skoore võrreldi mängusiseselt raporteeritud heaolu, motivatsiooni ja hoiakute skooride ning mängu kasutamise aktiivsusega. Osalejate psühholoogiline heaolu pärast sekkumise lõppu oli paranenud. Tervisega seotud elukvaliteedi asemel vaadeldi KS-52 füüsilise heaolu alaskaala skoore, mis samuti pärast sekkumise lõppu olid paranenud. Motivatsioon ja hoiakud ei olnud seotud osalejate füüsilise ja psühholoogilise heaolu ega aktiivsema mängukasutusega. Hüpotees, et sekkumises kasutatavad küsimused võiksid tuvastada sarnaseid probleeme kui TRK ja KS-52 küsimustikud leidis osalist kinnitust. Tulemuste põhjal võib järeldada, et Triumfi sekkumine võib omada lapseea vähipatsientide populatsioonis psühholoogilisele heaolule positiivset mõju. Edasised teadusuuringud peaksid eelkõige analüüsima sekkumise mõju teistel populatsioonidel ning valideerima sekkumises kasutatavaid küsimusi.

Märksõnad: digitaalne terviselahendus; mobiilse tervise platvorm; m-tervis; tõsimäng; terviserakendus; psühholoogiline tugi; vaimne tervis; krooniline haigus; vähk; pediaatria

The Effect of Triumf Mobile Health Game on Psychological Well-Being and Health-Related Quality of Life Among Pediatric Cancer Patients: A Pilot Study

It has been estimated that non-communicable disorders (chronic illnesses) affect around 27% of children (Van Cleave, 2010). Examples of the most common chronic illnesses include cardiovascular disease, cancer, chronic respiratory disease, diabetes (American Academy of Pediatrics, 2019). The daily stressors related more specifically with childhood cancer are related to the changed role functioning compared to what the patient was performing before the illness (e.g. lagging behind at school, isolation due to hospital stays), the side effects or physical stressors of the treatment (e.g. pain, feeling sick, changes in appearance), and lack of full understanding about cancer and its causes (e.g. not understanding medical personnel language, concerns about the future; Compas, Jaser, Dunn, & Rodriguez, 2012). Subsequently, the new health condition may increase emotional distress, including feelings of worry, fear, sadness, irritation, anger, guilt, loneliness, and isolation (Wiener, Pao, Kazak, Kupst, & Patenaude, 2015). In relation to emotional distress, children with chronic illness have been found to hold a higher risk of developing emotional problems such as anxiety and depression (Butler et al., 2018; Hysing, Elgen, Gillberg, Lie, & Lundervold, 2007; Pao & Bosk, 2011). Psychological problems in turn are considered one of the factors contributing to treatment nonadherence (DiMatteo, 2004; Fielding & Duff, 1999). Additionally, the availability and quality of psychological support for chronically ill children is not unified (Feudtner et al., 2013), although considered an essential part of comprehensive care (American Diabetes Association, 2018; Kirch et al., 2016; Tark, Jõeveer, Tali, & Haljas, 2018).

Digital interventions

Digital health interventions have been used for more than 20 years (Barak, Hen, Boniel-Nissim, & Shapira, 2008), with many of the benefits and downsides well-established. For example, whilst digital interventions offer similar efficiency with face-to-face therapy, not all are suitable for diagnostics and preference for human interaction remains amongst some patients (Andersson & Titov, 2014). It is encouraged to take the benefits of the interventions into use at a larger scale as it is argued that providing digital encounters at multiple touchpoints across the healthcare journey would enable cost-effectiveness and reach more individuals in need (Andersson, 2016). The benefits and effectiveness of digital health interventions have also been shown in child and adolescent patient groups (Pennant et al.,

2015; Richardson, Stallard, & Velleman, 2010), further highlighting the multifaceted opportunity that digital solutions offer.

The means of delivering digital health interventions to children and youth include, for example, telecommunications (e.g. videoconferencing, emailing, phone counselling) and mobile health (mHealth; smartphones, smartwatches, virtual reality; Boydell et al., 2014; Hollis et al., 2016). Advantages of these means involve satisfaction similar with face to face sessions, therapy effectiveness, improved access, enabling personalized and preventive approach through symptom monitoring possibility, and less stigma (Boydell et al., 2014; Hollis et al., 2016). Children and young people have been found to highly value the anonymity and privacy, share more detailed information and have higher compliance via digital tools (Boydell et al., 2014). On the other hand, disadvantages involve potential misinterpretations, impersonality due to the perceived distance, and differences in access to digital tools referred as the “digital divide” (Boydell et al., 2014).

Mobile health game Triumf

A mHealth platform Triumf (Figure 1) is an intervention for children aged 7-14 years that aims to detect, prevent and/or reduce the potential psychological problems resulting from chronic illness (Tark, Suarez, Metelitsa, Akkermann, & Haljas, 2018). The platform is targeted to school-aged children and covers most of the middle childhood years (Huston & Ripke, 2006), where the combination of developmental and chronic illness concerns may be more challenging. During middle childhood children go through changes that also include cognitive development, self-concept and identity, and where relationships with peers become more important and complex (Hay, Payne, & Chadwick, 2004; Huston & Ripke, 2006). The wide age range of Triumf intervention is mainly dependent on the textual presentation of in-game information and where younger players are able to read less complex language.

The intervention is delivered through a mobile game and consists of the following modules: screening module (psychological and general well-being, motivation and attitudes), educational module (information about the illness, treatment, and its relevant aspects), support module (psychological support, understanding emotions, health behavior change), and mini-game module (storyline, entertainment games, cognitive distraction, cognitive challenge). The intervention is based on the principles of serious games and its theoretical base includes Self-Determination Theory (SDT) and theories of emotions, psychological support, and behavioral change, which are described in detail in the following sections. Triumf mobile game conforms

to the World Health Organization's classification of digital health interventions category "targeted for clients" (1.1.2 Transmit targeted health information to client(s) based on health status or demographics; World Health Organization, 2018). In the National Institute for Health and Care Excellence (NICE) evidence standards framework for digital health technologies, the game conforms best to tier 3a evidence for effectiveness (best practice standard; NICE, 2019).

A serious game. A game can be defined through the components of story, art, and software, wherein a serious game can be determined by adding a component of pedagogy to the former, pedagogy staying subordinate to the story (Zyda, 2005). Research investigating gamification for digital interventions aimed at improving health has shown generally positive findings and the focus has turned from establishing effectiveness of the whole intervention to identifying the most effective elements (Hollis et al., 2016; Miller, Cafazzo, & Seto, 2016). More broadly, there has been a shift in research that is adjusting the focus from studying the negative impacts only to also considering the benefits that playing digital games might have (Granic, Lobel, & Engels, 2014; Ryan, Rigby, & Przybylski, 2006).

Self-Determination Theory. SDT is widely studied and has found application in several contexts, including mental health (Ryan & Deci, 2000; Ryan & Deci, 2008), video games (Ryan et al., 2006), and health behavior change (Ng et al., 2012; Ryan, Patrick, Deci, & Williams, 2008). SDT proposes that when needs for autonomy, competence, and relatedness are fulfilled, better self-motivation and mental health are achieved (Ryan & Deci, 2000). SDT also proposes that should the perception of autonomy, competence and relatedness be fulfilled, better health-related outcomes would be observed (Ryan et al., 2008). SDT has also been studied in a game setting, where SDT model was shown applicable to players motivation to play (the Player Experience of Need Satisfaction; Ryan et al., 2006).

From the above evidence, it could be estimated that Triumf mobile health game could enhance player autonomy through offering non-controlling guidelines and flexibility in choosing the sequence of tasks and goals, and by using in-game rewards as feedback instead of behavior-controlling mechanisms (Ryan et al., 2006). Competence could be enhanced through expanding knowledge about the illness and learning of the importance of treatment adherence, using rewards and/or praise for successfully completed health-related actions, and by keeping the players optimally challenged (e.g. possibility to choose the difficulty level in mini-games; Ryan et al., 2006). It has been shown that relatedness could be increased in the setup of multiplayer games (Ryan et al., 2006), but it could also be possible through creating

an environment the player can relate to (e.g. incorporating illness-related but also regular child activities) and where the player can communicate and play against the game (e.g. interacting with and helping the city kids, playing tic-tac-toe against artificial intelligence). All the presented means how to fulfil the perception of autonomy, competence, and relatedness in a game are integrated to Triumf mobile game.

Figure 1. Visual representation of the Triumf mobile health game

Understanding emotions. Poor understanding of emotions and emotion regulation has been found to be a risk factor in developing psychopathology (Aldao, Nolen-Hoeksema, & Schweizer, 2010; McLaughlin, Hatzenbuehler, Mennin, & Nolen-Hoeksema, 2011). At the same time, training to better understand one's emotions has proven to be effective on emotion regulation (Sprung, Münch, Harris, Ebesutani, & Hofmann, 2015). Triumf game provides information about the six basic emotions (Ekman, 1992) and players also are challenged to apply this knowledge in the city environment by recognizing the same emotions in city kids. Additionally, players are asked to report daily how they are feeling at the time on a circumplex of emotions. The circumplex is based on two orthogonal bipolar dimensions – positive-negative emotional state (happy-unhappy) and high-low activation level (aroused-still; Yik, Russell, & Steiger, 2011) – and encloses the following twelve emotions: aroused, energetic, enthusiastic, happy, peaceful, relaxed, still, tired, sad, unhappy, tense, and nervous. This helps to broaden the players' knowledge and understanding beyond basic emotions.

Psychological support. The general and psychological well-being of the players is monitored throughout the game. Players answer questions that include symptoms related to depression, anxiety, and attention problems, as well as to questions about general health.

Depending on the answer, psychological support feature prompts either psychoeducation, psychological coping technique, or praise. Evidence-based therapeutic techniques, which have been effective in the context of chronic illnesses, such as cognitive behavioral therapy techniques, relaxation, imaginary and distraction (Beale, 2006; Bennett, Shafran, Coughtrey, Walker, & Heyman, 2015; Pai & McGrady, 2014), are the basis for the psychological support offered through the game.

Behavior change. It has been shown that digital behavior change interventions for health are promising and effective, especially when the intervention techniques are theoretically grounded (Glanz & Bishop, 2010) and design considers user engagement (Kelders, Kok, Ossebaard, & Van Gemert-Pijnen, 2012; Vandelanotte et al., 2016). On the other hand, time needed for a new habit to form could be highly individual (Lally, van Jaarsveld, Potts, & Wardle, 2010) and therefore, within the limited intervention time one cannot guarantee a maintained behavior change. Triumf mobile health game could support change in relevant health behaviors such as diet and physical activity by incorporating information about the benefits of those behaviors in the context of the player's health condition, by increasing player's self-efficacy through encouragement, by offering problem solving approaches, by incorporating health behaviors to mini-games and other relevant tasks to progress in the game (e.g. help city kids to stay hydrated, keep the game character physically active), and reward those behaviors, to name a few (Abraham & Michie, 2008).

In sum, Triumf mobile game aims to help chronically ill children to better cope with their health condition by providing them illness- and treatment-related information and conveying the message of their own active role in the treatment process. Through gameplay, Triumf aims to help children understand how they can further the treatment with healthy behaviors, help them learn about emotions to better understand oneself, and find timely external psychological support, if necessary. The game does not include strict guidelines how to progress in the game, making it possible for the players to access components most relevant to them.

Objectives

The current study is a non-randomized pilot study and has three main objectives. First, as the intervention aims to have a positive effect, to evaluate the potential within-person effect of Triumf intervention on pediatric cancer patients' psychological well-being and health-related quality of life (HRQoL; based on validated questionnaires). Second, to examine how

in-game reported motivation and attitudes could be associated with in-game and questionnaire reported general and psychological well-being. Third, to examine the correspondence of the in-game questions of general and psychological well-being, and HRQoL. The hypotheses are:

H1. The intervention improves psychological well-being and HRQoL, resulting in improved questionnaire scores after the study period compared to baseline.

H2. Higher scores on motivation and attitudes result in better psychological well-being and HQRoL, and in a more active use of the intervention.

H3. In-game reported symptoms of depression, anxiety, and attention problems are in accordance with psychological well-being assessed by validated questionnaire.

H4. In-game reported general health is in accordance with HRQoL assessed by validated questionnaire.

Method

Participants

The current study sample consisted of pediatric cancer patients treated at Tallinn Children's Hospital and Tartu University Hospital. All patients aged 7-14 years, with new or recurrent cancer, diagnosed no more than one year ago, were invited to participate in the study by their medical doctors. Recruitment took place between June and October 2018. In total, 15 patients were invited to participate, out of whom 10 (67%) agreed to participate. One participant withdrew and therefore, the final sample consisted of nine (9) participants (4 girls, 5 boys, M_{age}=9.1 years, age range: 7-12 years), seven (7) with Estonian as first language and two (2) with Russian as first language. Sample characteristics are presented in Table 1.

All participants were provided with Android operating smartphones for the study period and there was no remuneration offered. Participants were able to fully access the intervention in their first language (Estonian or Russian). Informed consents were obtained both from one of the parents and the participants. Emails created by the research personnel were used to access the game, i.e. full anonymity of the game data in the database was ensured. Only personal identification codes were used for questionnaires. The study was approved by the Research Ethics Committee of the University of Tartu (decision 283/T-32).

Procedure

Medical doctors recruited the patients to the study based on the eligibility criteria. Patients who agreed to take part in the study, participated in a 60-day digital health intervention. The intervention was delivered through mobile health game Triumf and the suggested gameplay was 10 minutes per day. After the study, information about treatment was obtained from medical doctors, including the diagnosis, time from diagnosis, time spent at the hospital and at home, notification of medical treatment that could affect mood, cognitive functions, or cause fatigue.

Participants and one of their parents filled in two questionnaires – Strengths and Difficulties Questionnaire (SDQ) and KIDSCREEN-52 (KS-52) – at two time points: before and after intervention (hereon, pre- and postintervention will be used accordingly). For participants aged 7-10 years, only SDQ parent-report was asked to fill in and for participants aged 11-14 years, both self- and parent-report of SDQ.

Based on the results of the validated questionnaires (SDQ and KS-52), feedback was given to participants at both time points. Furthermore, doctors received feedback on the mental health status of the patient if there was an indication for an immediate psychological support. In informed consent it was highlighted that medical doctors, and not the research personnel, were making treatment decisions based on the study's screening results, including the need for psychological treatment.

Measures

Strengths and Difficulties Questionnaire. SDQ with impact supplement, measuring adjustment and psychopathology in children aged 3-16 years (Goodman, 2001), was used to screen psychological well-being. SDQ is a screening tool with high specificity and good sensitivity (Goodman, Ford, Simmons, Gatward, & Meltzer, 2000), also validated in chronically ill children sample (Hysing et al., 2007). SDQ consists of 25 questions organized into five subscales – emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems, prosocial behavior – with the first four subscales forming the total difficulties score and impact supplement evaluating the effect of the strengths and difficulties subscales on everyday life (home life, friendships, classroom learning, leisure activities). Higher scores indicate more problems.

Self-report questionnaires were filled in by participants who were 11 years or older and parent-reports were filled in by all participants. In the final analyses, only parent-report of the questionnaire was included as self-report was, due to the age restriction, filled in only by one participant. In the current study, emotional symptoms subscale that measures affective disorders and total strengths and difficulties score that measures the presence or absence of any psychiatric disorder (Goodman et al., 2000), were observed and included in analysis as an indicator of psychological well-being. As no SDQ self-reports were included in analysis, parent-reported scores were not included to H3 and H4 analysis.

KIDSCREEN-52. KS-52, measuring generic health-related quality of life among children aged 8-18 years was used to screen HRQoL. KS-52 is a screening tool with established reliability and validity and is intended to measure healthy and chronically ill children's HRQoL (Ravens-Sieberer et al., 2005, 2008).

KS-52 consists of 52 questions, which form ten subscales: physical well-being, psychological well-being, moods and emotions, self-perception, autonomy, parent relations and home life, financial resources, peer and social support, school environment, bullying. Lower scores indicate more problems.

All participants and one of their parents filled in KS-52. Question number six (*Have you felt pleased that you are alive?*) from psychological well-being scale was removed as being too delicate. Due to missing responses in several subscales, general HRQoL was not possible to calculate and was therefore excluded from analysis. Only the following intact subscale scores were obtained and included in the analyses: physical well-being, psychological well-being, moods and emotions. Physical well-being measures energy levels and capabilities of being physically active, psychological well-being experiencing positive emotions and satisfaction with life, and moods and emotions measures experiencing depressive mood and emotions (The KIDSCREEN Group Europe, 2006). For H3 and H4, only KS-52 self-reports were included in analyses as in-game scores were also self-reported and KS-52 self- and parent-reports were strongly correlated.

In-game self-reported well-being. At the beginning of the game, players are guided through the narrative of taming the Disease Monster, that has gotten loose in Triumfland City. During the guided introduction to the game, a total of eight modified questions from SDQ emotional and attentional problems subscales (Goodman, 2001) are used to profile players' baseline issues. Based on the resulted profile, the player is categorized as a) in good

psychological functioning, b) in need of psychological support for emotional problems, or c) in need of psychological support in more than one area. Based on the in-game category, questions about psychological and general well-being are prompted, and psychological support is offered accordingly two times per day or more frequently. Questions involve the following categories: symptoms of depression, anxiety, and attention problems, and general health (e.g. *Do you feel that what happens is your fault, Do you worry a lot?, Are you easily distracted by things around you?, Do you have a runny nose or cold?*). Depending on the answer to the question, psychoeducation, psychological coping technique, or praise is offered, as mentioned previously. Lower scores indicate more problems.

To observe the potential in-game reported within-person change during the intervention period, the following two scores of symptoms of depression, anxiety, attention problems, and general health were included in analysis: the average score of the answers reported on the first week using the intervention and the averages score of the answers reported on the last week using the intervention. As the first and last week average scores could be dependent on the possible sparse number of questions answered on the first or last week, a whole study period average score, which is the average of the total amount of questions answered for each category (symptoms of depression, anxiety, attention problems, and general health), was also calculated. Additionally, the total number of well-being questions answered throughout the study period was included in the analysis. The named variables were included in the analysis based on the results reported by Tark and colleagues (manuscript submitted for publication, Tark et al., 2019).

In-game self-reported motivations and attitudes. SDT questions about autonomy, competence, relatedness (healthcare climate), and general attitude towards health are included in the game (e.g. *I follow my treatment regimen regularly because others would be upset with me if I didn't, I feel confident in my ability to have a healthy lifestyle, I feel my physician understands me and my needs, It is important for me to be healthy*), wherein one of the outlined questions is asked every seven days. Presentation of the in-game questions is on a 1-7 visual scale (slider) where higher scores indicate better perceived autonomy, competence, healthcare climate, and attitude. Total SDT score, an average score of the autonomy, competence, relatedness, and general attitude towards health questions answered throughout the study period, were included in the analysis based on results reported by Tark and colleagues (manuscript submitted for publication, Tark et al., 2019).

Game activity. In addition to the psychological module, the intervention also consists of several mini-games. The cumulative time of active interaction with the intervention was not possible to calculate due to technical restrictions and therefore the results of the variables that indicate game activity indirectly were included in the analysis. These variables include total time spent in all mini-games, total amount of collectables gathered, and total amount of interactions with citizens initiated (helping citizen maintain health behaviors, such as hydration and dental hygiene).

Statistical analyses

A free statistical software JASP (https://jasp-stats.org) was used for data analysis. Due to the indicative nature of the current pilot study, parametric tests and Pearson correlation were used. Paired samples t-test was used to evaluate differences in pre- and postintervention SDQ and KS-52 scores, and in in-game reported psychological and general well-being scores. Independent samples t-test was used to evaluate differences in sex. Pearson correlation was used to explore associations between pre- and postintervention SDQ and KS-52 scores and a) in-game self-reported symptoms of depression, anxiety, attention and general health first week average, last week average and study period average; b) study period average SDT score; c) total time spent in mini-games (in minutes), exploring in the city environment (amount of collectables), and helping city kids maintain healthy behaviors (amount of interactions); d) treatment that could affect mood (in days), time spent at home (in days), time spent at hospital (in days), time from receiving diagnosis (in months). Data imputation was not used to replace missing data points. Pearson correlations between -1.0 and -.50 and .50 to 1.0 were observed, whereas correlations from .50 to .69 (-.50 to -.69) were considered as moderate and correlations from .70 to 1.0 (or -.70 to -1.0) as strong (Moore, Notz, & Flinger, 2013). Cohen's d .20 was considered small, .50 as medium and .80 as large effect size and should be interpreted as indicative as being the rule of thumb for effect sizes (Durlak, 2009). A conventional level for significance ($p < .05$) was used.

Results

Sample characteristics

Sample characteristics are presented in Table 1. The average time from diagnosis to the intervention was 5.3 months (*SD*=4.12, range: 0-12 months) and treatment that could influence emotional state and/or cognitive abilities was received, on average, on 12.7 days (*SD*=18.49, range: 0-60). One patient had a new diagnosis (time from diagnosis less than a

month), whereas the majority of participants had been on treatment or had a recurrent form of the illness for at least two months. On average, participants spent 17.2 days (*SD*=15.75, range: 0-37) at the hospital and 42.8 days (*SD*=17.75, range: 23-60) at home. None of the participants received systematic psychological support during the intervention period.

Participants spent on average 25.4 minutes (*SD*=19.60) playing mini-games, explored the city environment by collecting 199.3 items (*SD*=121.58) and initiated on average 74.2 interactions (*SD*=67.86) with the citizens. There were no statistically significant differences between boys and girls in SDQ or KS-52 scores, in-game reported well-being, motivation and attitudes, or game behavior.

Table 1

Sample Characteristics

Variable	*n* or *M* (% or ±SD)
Sex	
Girls	4 (44%)
Boys	5 (56%)
Age (years)	9.1 (±1.45)
Language	
Estonian	7 (78%)
Russian	2 (22%)
Diagnosis category	
CNS tumor	1 (11%)
Leukemia	6 (67%)
Other	2 (22%)
Treatment status	
Newly diagnosed	1 (11%)
On treatment	6 (67%)
Recurrent	2 (22%)

Mean scores of SDQ and KS-52 are reported in Table 2. KS-52 self- and parent-reports presented several statistically significant correlations considering preintervention

scores: self-reported physical well-being was in strong positive correlation with parent-reported physical well-being (r = .90, p < .001). Self-reported psychological well-being was in moderate positive correlation with parent-reported psychological well-being (r = .67, p = .047). Self-reported moods and emotions were strongly positively correlated with parent-reported moods and emotions (r = .88, p = .002).

Postintervention self-reported moods and emotions were strongly positively correlated with parent-reported moods and emotions (r = .89, p = .001), whereas other correlations did not remain statistically significant. Of note, out of the nine parents, eight (89%) were mothers.

In-game reported well-being and motivation and attitudes. Based on the in-game profiling, eight participants (89%) fell to the good psychological functioning category and one to the in need for psychological support in more than one area category. This latter participant was the only one from the sample who was newly diagnosed, and who also reported lower scores for in-game depression and anxiety symptoms, pre-and postintervention psychological well-being, and played the game less compared to other participants.

Table 2

T-test Comparison of Pre- and Postintervention SDQ and KS-52 Scores

	Preintervention Mean (SD)	Postintervention Mean (SD)	*t-value*	*p*	*d*
SDQ emotional problems	2.44 (±1.74)	1.67 (±1.73)	1.941	.088	.44
SDQ total difficulties	7.78 (±4.38)	5.44 (±3.97)	1.923	.091	.56
KS-52 physical well-being (parent)	13.67 (±4.90)	15.78 (±5.36)	-1.566	.156	.41
KS-52 psychological well-being (parent)	15.22 (±3.11)	17.33 (±2.69)	-1.820	.106	.73
KS-52 moods and emotions (parent)	30.22 (±3.15)	31.78 (±1.92)	-2.401	.043*	.60
KS-52 physical well-being (self)	14.00 (±4.44)	16.67 (±5.52)	-1.592	.150	.53
KS-52 psychological well-being (self)	18.00 (±4.12)	19.33 (±3.24)	-0.770	.464	.36
KS-52 moods and emotions (self)	30.22 (±3.27)	32.11 (±2.57)	-2.392	.044*	.64

Note. SDQ higher scores indicate more problems, KS-52 lower scores indicate more problems.
* p < .05

Participants answered on average 66.6 (*SD*=51.56, range: 5-159) in-game well-being questions and received psychoeducation, psychological coping techniques, or praise

accordingly. Comparisons between the first and last week reported well-being showed no statistical significance for depression, anxiety, and attention problems. There was a statistically significant change for general health, resulting in less problems ($t(7) = -4.399$, $p = .003$).

On average, participants answered 8.1 (range: 1-12) SDT questions out of 14 possible and the average SDT score of all participants was 5.5 (*SD*=1.03 range: 3.7-7). Comparisons between the study period's average SDT scores during the first and last week indicated a slight increase in motivation and attitudes (6.13 to 6.35, $p = .521$); manuscript submitted for publication, Tark et al., 2019).

Potential improvement in psychological problems

The results of the paired samples t-tests are presented in Table 2. There were no statistically significant changes in neither of the pre- and postintervention parent-reported SDQ subscales, although total difficulties subscale had a medium effect size ($d = .56$) and there was an improvement in emotional problems and in total difficulties score (Table 2).

For KS-52, there was a statistically significant change in self-reported moods and emotions ($t(8) = -2.392$, $p = .044$, $d = .64$) and parent-reported moods and emotions ($t(8) = -2.401$, $p = .043$, $d = .60$). There was no statistically significant change in parent- or self-reported KS-52 physical well-being and psychological well-being scales, although parent-reported psychological well-being and self-reported physical well-being had medium effect sizes ($d = .72$ and $d = .53$ accordingly) and there was an improvement in scores on both subscales for both reports (Table 2).

Higher motivation and attitudes potential to result in better psychological well-being and HRQoL

SDT score did not present any significant correlations with emotional problems or total difficulties, and neither with KS-52 psychological well-being, moods and emotions subscales, nor game behavior. A significant and strong positive correlation was noted for time passed from receiving diagnosis ($r = .70$, $p = .037$). A nonsignificant but moderate correlation was observed with preintervention self-reported physical well-being ($r = .58$, $p = .104$) and preintervention parent-reported psychological well-being ($r = .55$, $p = .127$).

Correspondence of in-game and validated questionnaire measures

Several statistically significant associations or moderate correlations were found between in-game self-reported psychological well-being and KS-52 self-reported psychological well-being and moods and emotions subscales (Table 3).

Psychological well-being intervention period average in-game scores were associated with the following validated questionnaires: 1) average scores of depression were in positive moderate correlation with KS-52 preintervention moods and emotions (r = .55, p = .123) and in strong correlation with postintervention psychological well-being (r = .72, p = .029); 2) average scores of anxiety were positively correlated with preintervention moods and emotions (r = .56, p = .118); and 3) average scores of attention problems were correlated with postintervention reported moods and emotions (r = .56, p = .12).

Last intervention week in-game psychological well-being averages were associated with postintervention validated questionnaires as follows: 1) symptoms of depression were moderately correlated with postintervention (r = .58, p = .136) moods and emotions, and postintervention psychological well-being results (r = .81, p = .015); 2) anxiety symptoms were positively correlated with postintervention KS-52 psychological well-being (r = .82, p = .025), and moods and emotions (r = .57, p = .181).

First intervention week in-game psychological well-being averages were associated with preintervention validated questionnaires only with in-game attention problems reported on the first week of using the intervention and preintervention KS-52 physical well-being (r = .77, p = .043). All correlations are presented in Table 3.

Some statistically significant associations or moderate correlations were also found between in-game self-reported general health (general well-being) and KS-52 self-reported physical well-being (Table 3).

Intervention period average general health was positively correlated only with preintervention KS-52 physical well-being, although not statistically significant (r = .55, p = .128). Intervention period average general health score was, however, in statistically significant correlation with both preintervention (r = .70, p = .036) and postintervention (r = .76, p = .029) KS-52 moods and emotions result. Additionally, associations between KS-52 physical well-being and in-game reported psychological well-being were observed. Preintervention reported physical well-being was correlated with first week reported attention

problems (r = .77, p = .043) and postintervention reported physical well-being was correlated with last week reported anxiety (r = .83, p = .021).

Table 3

Correlations Between In-game Reported Well-Being and Self-Reported KS-52

	depr_1	depr_2	depr_avg	anx_1	anx_2	anx_avg	att_1	att_2	att_avg	heal_1	heal_2	heal_avg	PHY_1	PWB_1	EMO_1	PHY_2	PWB_2	EMO_2
depr_1	—																	
depr_2	.69	—																
depr_avg	.90***	.91**	—															
anx_1	.46	.77*	.57	—														
anx_2	.27	.52	.36	.42	—													
anx_avg	.49	.87**	.61	.87**	.70	—												
att_1	.10	.08	.17	.22	-.08	-.03	—											
att_2	.12	-.09	-.07	-.14	.22	.13	-.67	—										
att_avg	.19	.77*	.38	.48	.26	.68*	-.07	.41	—									
heal_1	-.01	-.05	.09	-.26	.05	-.13	-.71	.04	-.25	—								
heal_2	.02	-.27	-.07	-.23	.29	-.06	-.52	.41	-.22	.66	—							
heal_avg	-.07	.28	.21	-.15	.51	.07	-.10	-.32	-.08	.69*	.39	—						
PHY_1	.03	.30	.27	.00	.39	.07	**.77***	-.33	.15	-.04	.17	.55	—					
PWB_1	.04	.44	.28	.48	.24	.40	.36	-.09	.29	.21	.50	.35	.58	—				
EMO_1	.17	**.76***	**.55**	.48	**.52**	**.59**	.31	-.38	.45	.27	.07	**.70***	.67*	.71*	—			
PHY_2	.40	.26	.35	-.06	**.83***	.22	.11	.20	-.08	.04	.39	.42	.51	.09	.21	—		
PWB_2	**.65**	**.81***	**.72***	.37	**.82***	.49	.18	-.21	.06	-.07	-.22	.34	.33	.02	.41	.72*	—	
EMO_2	.02	**.58**	.32	.03	**.57**	.41	-.24	.05	**.56**	.36	.07	**.72***	.39	.18	.70*	.30	.33	—

Note. depr = depression symptoms, anx = anxiety symptoms, att = attention problems, heal = general health; PHY = physical health, PWB = psychological well-being, and EMO = moods and emotions; number 1 = either preintervention or first intervention week measurement, number 2 = either postintervention or last intervention week measurement.

* $p < .05$, ** $p < .01$, *** $p < .001$

Discussion

The general aim of this pilot study was to explore the potential effect of Triumf mobile health game on the psychological well-being and health-related quality of life among pediatric cancer patients. The main findings of current study show that psychological well-being of the participants and KS-52 physical health subscale, observed as a broad approximate instead of generic HRQoL, improved after the intervention period. Due to the exploratory nature and statistical analyses applied in the current pilot study, the results are aimed to inform future studies and should be interpreted as indicative.

General HRQoL in its original purpose was not possible to obtain due to missing questionnaire data. However, three HRQoL subscales measuring physical well-being and the experience of positive and negative emotions were possible to measure. As HRQoL has found to be broad in terms of definitions (Karimi & Brazier, 2016), and taking into account the focus of the impact of a physical illness on the psychological and general well-being of an individual in the current study, one could very broadly derive an approximate for HRQoL only based on the observation of physical health. Therefore, physical well-being was observed as a broad approximate of HRQoL and experiencing negative and positive emotions were included in the analyses to observe psychological well-being.

Results regarding the first hypothesis indicated that after the intervention patients experienced less psychological problems. Change in HRQoL was observed as change in physical well-being, which also resulted in improved questionnaire scores. More specifically, both patients and their parents reported significant change and experienced more positive emotions after the intervention, accompanied by medium effect sizes. Further, there was also a trend towards better physical well-being and experience of less negative emotions after the intervention. Additionally, parents also noted a tendency for less emotional problems and difficulties in general. Although these tendencies were not statistically significant, some of them had medium effect sizes, which could be related to the small sample size and need further investigation. These results confirm the hypothesis that Triumf mobile health game could be used as an effective mean of intervention delivery (Hollis et al., 2016) and a potentially effective intervention offering psychological support. The physical and psychological well-being subscales of the patients, reported via validated questionnaires by both patients and their parents, were in accordance which gives further assurance on the validity of reports by young patients and the use of children`s self-reports in the mobile health intervention. Although none of the participants received systematic psychological support

during the intervention period, future studies should take into consideration the influence of other possibly confounding variables, such as time passing from diagnosis in the course of intervention, whether improvements in physical health are due to treatment or due to change in psychological well-being, and presence of various stressful or positive events during the intervention period, that could influence the child's psychological well-being.

Hypothesis that higher motivation and attitudes, i.e. higher perceived autonomy, competence, relatedness, and better attitudes toward one's health, would result in better psychological well-being and HRQoL after the intervention, and in a more active game behavior, was not supported. Although, higher motivation and attitudes were related with more time passed from receiving the diagnosis. This could imply that it is easier for patients to find motivation and value the importance of being healthy when there has been more time to adjust to the health situation and solve the daily stressors (Compas et al., 2012). What contributes to the motivation and attitudes of the patients and whether and how it is different among different chronic conditions warrants further investigation. The importance of monitoring motivation and attitudes towards one's health is, nevertheless, important as it has been found to be one of the factors relating to treatment adherence (Butow et al., 2010; DiMatteo, Haskard-Zolnierek, & Martin, 2012) and health behavior change (Ryan et al., 2008).

The correspondence of the in-game and external psychological well-being measures and therefore, the potential that Triumf intervention game could be able to determine similar psychological problems that validated questionnaires, found partial support. Patients reporting less symptoms of depression and anxiety in the game on the last week of using the intervention also reported experiencing more positive and less negative emotions after the intervention with a validated questionnaire. It is interesting that first week reported depression and anxiety symptoms were not associated with preintervention self-reported validated questionnaires, although this was the case postintervention. The finding that attention problems were not in accordance with reports by validated questionnaire likely reflects the fact that KS-52 does not include specific subscale for attention problems. The accordance of in-game and validated psychological well-being measures evident only at postintervention assessment needs further investigation. Additionally, the assessment of in-game attention problems needs further validation.

The fourth hypothesis was intended to evaluate the accordance between in-game reported general well-being and HRQoL measured with KS-52, however, physical health

subscale instead of generic HRQoL was mainly observed due to missing data. There were no statistically significant associations between patient-reported KS-52 physical health and in-game reported general health. KS-52 physical health compared to in-game reported psychological well-being showed a correlation with anxiety and attention problems at one time point only. Nevertheless, intervention period average for better in-game reported general health was related to experiencing less negative emotions before and after the intervention. This suggests a convincing relationship where better general health reported throughout the study period resulted in better psychological well-being. The differences in KS-52 physical health and in-game general health scores could reflect the different nuance of the questions included in in-game general health category (e.g. *Do you have a runny nose?* and *Do you eat healthily?*), which covers a broader range of health than just physical health. Therefore, the general health reported in-game was not in accordance with patient-reported physical health subscale and should be investigated further. Separating the current in-game general health into two new categories of physical well-being and health behaviors should be considered.

The strengths of this study include, first, the use of both self- and parent-reports of validated questionnaires to evaluate the potential effect of the intervention, which by correspondence confirmed the use of children's self-reports in the intervention. Secondly, the study was conducted in a clinical context, across two hospitals, enabling more generalizable results compared to a single-site study. Thirdly, theoretical base of the intervention was provided, which is crucial in enabling further analyses of the most effective components of the intervention (Hollis et al., 2016; Miller et al., 2016). Finally, including no human support in the delivery of the intervention would allow to further evaluate the potential cost-effectiveness of the intervention (Hollis et al., 2016)

There are, however, also several suggestions for the future studies. The intervention was used by patients in different stages of the treatment and there was a distinctive difference of game behavior and psychological functioning of the newly diagnosed patient compared to the remaining sample. This may suggest that the intervention should be modified for newly diagnosed patients or used at later stages of treatment from diagnosis. It may also suggest that patients with more symptoms of depression and/or anxiety are not activated enough to use the intervention, although this has not been found to be the case in an adult sample (Mandryk & Birk, 2017). Additionally, how to control for other contributing factors to the patients' psychological well-being and what is the effect of the intervention on health-related quality of life should also be addressed. Further, as the study sample was very modest, a longer

recruitment period should be considered, and possibly a comparison to other chronic illnesses could be included in the protocol. This would also increase the statistical power in interpreting the results. Furthermore, although SDQ and KS-52 are set to measure psychopathology and health-related quality of life among chronically ill children, the questionnaires do present some limitations. Although correspondence between self- and parent-reports was found, previous studies have found both correspondence and discrepancies between the reports (Becker, Hagenberg, Roessner, Woerner, & Rothenberger, 2004; Robitail et al., 2006; Robitail, Siméoni, Ravens-Sieberer, Bruil, & Auquier, 2007; van der Meer, Dixon, & Rose, 2008). SDQ's main limitation is the use of self-reports from 11 years of age. An alternative would be to evaluate symptoms of affective disorders more specifically, as the intervention is not targeted to improve all the problematic areas assessed by SDQ. KS-52 main limitation is its length, and although it aims to measure health-related quality of life subareas, many of the subscales are still strongly affected by pediatric cancer treatment, for example autonomy in a hospital setting is limited, self-perception is affected due to changes in appearance, school problems and bullying in the context of home-schooling could not be assessed. A more specific HRQoL measure should be used instead, or as KIDSCREEN has a high value due to self-report, KIDSCREEN-10, a shorter version of the measure, could also be considered as a possible alternative.

In summary, it could be concluded that Triumf mobile health intervention may have a positive effect on the psychological well-being of pediatric cancer patients aged 7-12 years. It could also be concluded that the intervention may have potential to determine similar psychological problems as validated questionnaires in some areas, although future studies are warranted to validate the questions presented in the intervention. Also, the impact of motivation and attitudes reported through the intervention on the player and on using the intervention call for further investigation. Nevertheless, it appears that a digital medium for monitoring the psychological well-being and offering psychological support could be an innovative solution to connect with patients and reach more children. Thereby it would be possible to unify the differences between psychological support availability among different hospitals or care centers, prevent psychological problems, and indicate a need for treatment before problems escalate through early detection.

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Conflict of interest

Riin Tark and Kadri Haljas are part of Triumf Health start-up and have been involved in the creation of the digital health intervention.

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