Feasibility and Usability of a Virtual Reality Intervention to Enhance Men's Awareness of Testicular Disorders (E-MAT)

Mohamad M. Saab [a,*]

Margaret Landers [a]

Eoghan Cooke [b]

David Murphy [b]

Josephine Hegarty [a]

[a] School of Nursing and Midwifery, University College Cork, Cork, Ireland

[b] Department of Computer Science, University College Cork, Cork, Ireland

***Corresponding author at:**

Mohamad M. Saab

School of Nursing and Midwifery, University College Cork, Brookfield Health Sciences Complex, College Road, Cork, Ireland, T12 AK54

Tel.: +353 21 490 1518

Fax: +353 21 490 1493

E-mail address: msaab@ucc.ie; mohamad.m.saab@gmail.com

ORCID ID: 0000-0002-7277-6268

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Abstract

Testicular cancer is the most common cancer among men younger than 50 and benign testicular disorders such, as torsion and epididymitis can be life threatening if left untreated. Men's awareness of testicular disorders is lacking and their intentions to see help for symptoms of testicular disease are low. This study aimed to describe the development, feasibility, and usability of a virtual reality (VR) intervention designed to enhance men's awareness of testicular disorders (E-MAT). We designed E-MAT as a three-level VR experience and tested its feasibility and usability with 15 men recruited from a university. Following exposure to the intervention, participants filled a 43-item questionnaire. Participants agreed that the technology was comfortable to use, testicular disorders were well represented, the use of light humor was appropriate, and the scientific facts were easy to understand. Participants also agreed that the intervention was suited for men from different sociodemographic backgrounds and felt confident using VR. Overall, participants perceived the intervention as user friendly, enjoyable, and aesthetically appealing. To the best of our knowledge, VR has not been used to promote men's health in the past, let alone increasing their awareness and help seeking for testicular disorders. We recommend testing the effectiveness of E-MAT and making it available on public platforms that men can access at their own leisure. VR can be used in future interventions to educate men about various health topics.

Keywords: Feasibility; health promotion; testicular cancer; testicular diseases; usability; virtual reality

1. Introduction

Globally, a significant health disparity exists between the two genders due to various factors, including men's disengagement with health services and the underrepresentation of men in health promotion research (Baker et al. 2014; Robinson and Robertson 2010). While a number of male-specific diseases do not get enough attention in the literature on health promotion, disorders of the testes are especially seldom discussed.

Testicular cancer (TC) predominantly affects men who are younger than 50 (Hashibe et al. 2016). The incidence of TC doubled over the past five decades and is highest in Western Europe, New Zealand, Australia, and the United States (Shanmugalingam et al. 2013). Surgical resection of the affected testis (i.e. orchiectomy) is the primary curative treatment for TC and is often followed by radiotherapy and/or chemotherapy (National Cancer Institute 2016). TC treatment is known to cause long-term complications including cardiovascular diseases, pulmonary toxicity, and infertility (Saab et al. 2014; Sprauten et al. 2012).

Benign testicular diseases are more prevalent than TC. One in 889 males is expected to develop testicular torsion by the age of 25 years (Shteynshlyuger and Yu 2013). Epididymo-orchitis, often sexually transmitted among men younger than 50, is the most common cause of testicular enlargement and pain. This disorder accounted for 1 in 144 outpatient visits among men aged 18 to 50 years in the United States (Trojian et al. 2009). Like TC, testicular torsion and epididymo-orchitis can cause complications ranging from minor discomfort to incapacitating pain, testicular ischemia, sepsis, and infertility (Bayne et al. 2017). Varicocele is another benign testicular disease characterized by a dilation of the veins in the testes (Wampler and Llanes 2010). This disease affects 10 to 20% of adolescents and young adults (Gordhan and Sadeghi-Nejad 2015). Hydrocele and spermatocele are rare benign testicular conditions that involve fluid collection in the testes (Rioja et al. 2011). Varicocele, hydrocele, and spermatocele are often asymptomatic and discovered accidentally (Saab et al. 2016a).

Despite reporting being aware of TC, men's knowledge of TC risk factors, symptoms, and treatment were lacking (Kennett et al. 2014; Powe et al. 2007; Saab et al. 2017a). As for non-malignant testicular diseases, men's awareness of testicular torsion was deficient in a study by Clark et al. (2011). These findings are echoed in a study on breast cancer awareness, whereby 88% of 1,255 women reported that they had heard of breast self-examination, yet 87% reported not performing this practice because they did not know how to examine their breasts (Yoo et al. 2012).

Interventions promoting awareness of TC and testicular self-examination exist. Examples include self-reflection and briefing (Kedzierewicz et al. 2011), print media (Evans et al. 2012; Brown et al. 2012; McCullagh et al. 2005; Umeh and Chadwick 2016), and awareness sessions (Shallwani et al. 2010). In contrast, no interventions exist to promote awareness of benign testicular disorders (Saab et al. 2016a). This requires research using targeted interventions to enhance awareness of testicular diseases, whilst using strategies that appeal to younger men (Saab et al. 2017b).

In this paper, we describe the development, feasibility, and usability of a virtual reality (VR) intervention designed to enhance men's awareness of testicular disorders (E-MAT).

2. Methods

2.1 Study design

A feasibility study was conducted to determine whether the E-MAT intervention can work, does work, and will work prior to conducting a pilot or definitive study (Orsmond and Cohn 2015; Whitehead et al. 2014). A usability study, on the other hand, helped evaluate the appropriateness of VR to the purpose of the E-MAT intervention (Brooke 1996, 2013).

2.2 The E-MAT intervention

The development, feasibility, and usability testing of the E-MAT intervention were guided by the Medical Research Council (MRC) framework for complex intervention development and testing (Craig et al. 2013). The evidence base was identified through conducting one integrative and two systematic reviews of the literature on men's awareness of testicular disorders (Saab et al. 2016 a, b, c), as well as a qualitative study exploring men's (n=29) awareness of testicular disorders, help seeking intentions for testicular symptoms, and preferred learning strategies in relation to testicular disorders (Saab et al. 2017a, b). Furthermore, the Preconscious Awareness to Action Framework was developed to underpin E-MAT (Fig1) (Saab et al. 2018b). The steps underpinning the development of E-MAT are summarized in Table 1.

E-MAT was designed using Unreal Engine 4.12 (UE4), a freely available game engine that supports the development of numerous platforms. The intervention was developed for use with a VR headset and controller with haptic feedback. A professionally recorded voiceover was delivered via headphones in order to provide prompts and scientific facts and help transition between the various levels. The script that guided the voiceover scored 83.4 on the Flesch-Kincaid test, indicating that it was suitable for sixth Graders and written using conversational English (Flesch 1981).

E-MAT comprised three level. The first level involved a 3D space with two walnuts that were used to represent the testes (Fig2). The user was required to move around the walnuts using the controller, while the voiceover provided information about the normal size and shape of the testes. A lump, swelling, and pain started appearing consecutively and were accompanied with lighthearted responses from the voiceover such as: “that doesn’t look good! that wasn’t supposed to be there! that escalated quickly! and so on.” Participants were required to walk towards the walnuts while using the controller and to “touch” each abnormality with the hand avatar, which triggered a humorous response from the voiceover and haptic feedback from the controller.

The second level involved a 3D model of a real testis with structures such as the spermatic cord and epididymis. During this level, the voiceover linked some of the abnormalities experienced in the first level to testicular structures. For example, a purple lump appeared on the surface of the testis to indicate a cancerous growth.

During the third level, the key messages from the intervention were reiterated, namely the importance of knowing one’s own testes, performing self-examination, and seeking timely medical attention for testicular symptoms.

2.3 Participants and procedures

The study was granted ethical approval by the Clinical Research Ethics Committee. Non-probability sampling was used to recruit men, residing in the Republic of Ireland, and aged between 18 and 50 years. Men with a history of VR sickness were not legible for inclusion. VR sickness is characterized by ocular (e.g. eyestrain, blurred vision, and pain) and/or non-ocular (e.g. fatigue, drowsiness, dizziness, and nausea) symptoms that rarely occur among VR users (Fernandes and Feiner 2016).

An e-mail was circulated to university students and staff inviting them to take part in the study and encouraging them to invite other men to participate. Data were collected in a VR lab. Participants were provided with a study information leaflet. The use of the VR headset and controller was explained and participants were notified about the risk of VR sickness. After providing written informed consent, participants were exposed to a short demonstration in order to become familiar with the technology. After which, they were exposed to the E-MAT intervention. Two researchers were present during testing to ensure that the participants did not experience any technical difficulties and did not develop VR sickness. Participants completed a questionnaire immediately following the intervention.

2.4 Instruments

Data were collected using a sociodemographic questionnaire with seven items, a feasibility scale, a satisfaction item, the System Usability Scale (SUS) (Brooke 1996, 2013), and open-ended questions that explored what elements of the intervention worked/did not work.

The feasibility of the technology, the representation of the testes, and the appropriateness of the intervention for men from different sociodemographic backgrounds were measured using a 21-item questionnaire. The level of agreement for each item was assessed on a 5-point Likert scale. Scores ranged between 1 and 5, with higher scores indicating greater feasibility. Cronbach's alpha was 0.9, indicating excellent reliability (Hinton et al. 2004).

Participants' overall level of satisfaction with the intervention was measured using a single item and assessed on a 5-point Likert scale ranging from "Extremely Dissatisfied" to "Extremely Satisfied." Scores ranged between 1 and 5, with higher scores indicating greater satisfaction. In addition, findings in relation to satisfaction were captured in the responses to the open-ended questions.

The 10-item valid and reliable SUS was used to assess the usability of the technology in terms of ease/complexity, functions, and level of confidence. The level of agreement for each item was assessed on a 5-point Likert. The scores per item were added and ranged between 0 and 4. The sum of scores was then multiplied by 2.5 in order to obtain an overall score ranging between 0 and 100 (Brooke 1996, 2013). Cronbach's alpha was 0.8, indicating high reliability (Hinton et al. 2004).

2.5 Data Analysis

Descriptive statistics were used to describe the sample characteristics and study variables. These included frequencies and percentages for categorical variables, and measures of central tendency (mean and median), and dispersion (minimum, maximum, standard deviation [SD], and interquartile range [IQR]) for continuous variables. Content analysis was used to analyse findings from open-ended questions (Elo and Kyngäs 2008).

3. Results

A total of 15 men participated in this study. Participants were aged between 19 and 31 years (Mean 26, SD 3.8). On average, it took the participants five to six minutes to complete the intervention. The sociodemographic characteristics of the study participants are presented in Table 2.

3.1 Feasibility

The majority of participants (n=12) agreed that the headset was comfortable and none found the elements of the intervention confusing. All 15 participants agreed that the controller was easy to use; the testes were well represented using walnuts; testicular pain, swelling, and lumps were well represented; and the verbal instructions provided by the voiceover were clear. In addition, 14 participants agreed that the elements of the intervention were humorous; the font, color, and size of the written words were clear; the 3D testis in the second level was well represented; and the scientific facts provided by the voiceover were easy to understand.

As for the appropriateness of the intervention, 14 participants believed that the intervention would work with men aged 18 to 50 years and men with different sexual orientations. The majority of the participants (n=10) agreed that the intervention would work with men from different educational backgrounds; the remainder were either neutral (n=4) or in disagreement (n=1). All 15 participants found the intervention to be applicable to real life and 14 believed that they have learned something valuable. The mean score on the feasibility scale was 4.5 (SD 0.3, range 4-4.9). Findings from the feasibility scale are presented in Table 3.

3.2 Satisfaction

All 15 participants were either "Satisfied" or "Extremely Satisfied" with the intervention (Median 5, IQR 4 to 5). One participant stated that he *"did not expect to be so engaged on a topic so technical"* and that *"technical terms and definitions were well-tempered to suit a non-medical audience."* Also, *"the use of vibrations to indicate problems was very effective"* for one participant. Another participant believed that the intervention was *"very enjoyable, relatable, and fun."* One participant stated that he was *"impressed with the information provided in such a short space of time"* and another stated that he was *"very impressed by the overall aesthetic packaging of the intervention."*

3.3 Usability

Overall, 14 participants agreed that they would like to use the system frequently. All 15 participants believed that the system was easy to use, found that the different functions within the system were well integrated, believed that people would learn how to use the system quickly, and reported feeling very confident using the system. Participants did not think that the system was complex; that they needed assistance to use VR; that there was inconsistency in the system; that the system was cumbersome; and that they needed to learn many things before using the system. The overall score on the SUS was 91.7. Findings from the SUS are presented in Table 4.

3.4 Open-Ended Questions

When asked what elements of the intervention worked for them, participants identified the following: the interactive aspect of the intervention; the information provided by the voiceover in terms of clarity, conciseness, and humor; the use of walnuts to represent the testes; the representation of testicular symptoms; being able to move around the walnuts and view them from different angles; haptic feedback from the controller; the hand avatar used to find changes; and the ease of control and immersion in the VR experience.

As for the elements that did not work, some participants reported that the finer details were hard to see and suggested a prior explanation of the use of sound to indicate direction. One participant suggested that the voiceover could adopt a stronger tone and another reported that the icons used in the final level were difficult to read. One participant was unsure whether the scientific facts in relation to the epididymis were clearly explained.

Overall, participants stated that they would not change anything in the intervention as they *"really enjoyed it."* One participant stated that he would improve the graphical quality of the *"inside look."* Others suggested placing the walnuts in the bathroom or shower, elongating the spermatic cord, seeing more of the testis, and having more textual information.

4. Discussion

Overall, participants were positive that the intervention would work in terms of layout and content and were comfortable using the technology. These findings were echoed in a number of feasibility studies conducted in different health contexts. For example, Oliveira et al. conducted a study to discuss the development and feasibility of a VR intervention aimed at assessing cognitive functioning in older adults (Oliveira et al. 2016). The intervention was found to be feasible and appropriate for older adults, including those who were not familiar with the technology. Another example is a study conducted to assess the feasibility of a VR interface in promoting motor rehabilitation (Foreman and Engsberg 2017). Overall, participants perceived the interface as motivating, engaging, and safe.

The usability of the E-MAT intervention was established using the valid and reliable SUS. Likewise, the usability of a number of VR-based interventions has been established using the same instrument. For instance, Dhiman et al. used the SUS to evaluate the usability of a VR-based rehabilitation intervention with audio, visual, and haptic feedbacks (Dhiman et al. 2016). The intervention was perceived as user-friendly and potentially effective in the rehabilitation of patients with upper limb movement disorders. Similarly, high SUS scores have been reported in a randomized controlled trial evaluating the effectiveness of a VR-based tele-rehabilitation programme among patients with stroke (Lloréns et al. 2015). Of note, VR is gaining popularity in mental health research and VR exposure therapy is being increasingly used in the management of phobias including fear of spiders (Miloff et al. 2016), and fear of flying (Cardoş et al. 2017). On the other hand, the use of VR to promote men's health is lacking (Saab et al. 2016a, b).

Participants in the present study highlighted the feasibility of using visual, auditory, and haptic feedbacks in raising testicular awareness. Similar findings have been reported in a review of studies on multimodal feedbacks (Sigrist et al. 2013), whereby visual, auditory, and haptic feedbacks were perceived as most applicable to real life. This was reflected in a number of contexts such as robot-assisted surgery (van der Meijden and Schijven 2009); medical education (Lemole et al. 2007); neuro-rehabilitation (Gomez-Rodriguez et al. 2011); management of chronic illnesses (Oosterom-Calo and López 2016); social cognition training (Kandalaft et al. 2013); and cardiac life support training (Vankipuram et al. 2014).

The use of light humor was highlighted as an effective aspect of the E-MAT intervention. The use of humor is not uncommon in studies involving men. An example is a study conducted among prostate cancer survivors, whereby humor was instrumental in promoting inclusivity and discussions about sexual health (Oliffe et al. 2009). Moreover, a humorous public service announcement was effective in increasing men's intentions to perform testicular self-examination (Nabi 2016). However, a review of best practice in teaching men to perform testicular self-examination found that "cheeky humor" and puns were perceived as offensive and proved ineffective in increasing testicular self-examination (Thornton 2015). This was reflected in the qualitative study that helped us develop E-MAT, whereby men recommended using light humor and lighthearted messages rather than humor that can be offensive to men in general and survivors of testicular disorders in particular (Saab et al. 2017b).

In the present study, we hypothesized that a VR-based intervention was feasible for men in general and younger men in particular. This was based on findings from the qualitative study that underpinned the development of the E-MAT intervention, whereby men recommended moving away from traditional strategies, such as print media, and stressed the importance of innovative and stimulating strategies (Saab et al. 2017b). In fact, 14 of the 15 participants in this study agreed that the intervention was suited for men aged 18 to 50 years. These findings were echoed in a study that compared the use of technology in education between male and female students (He and Freeman 2010). It was found that males were more computer-oriented and reported greater computer self-efficacy than females. Evidence also suggests that younger men are more likely than older men to engage with health information delivered using technological means (Jensen et al. 2010).

Despite using a demonstration to familiarize men with the technology, writing the voiceover script using a language suited for sixth Graders, and ensuring sociocultural neutrality, some participants did not agree that the intervention would work with men from different educational backgrounds. In fact, a systematic review of 31 studies exploring men's information-seeking behaviors in relation to cancer prevention found that men with low literacy levels were unlikely to engage with interventions involving technology (Saab et al. 2018a).

A number of limitations are worthy of note. A key limitation is the risk of VR sickness, which usually resolves upon removing the VR headset. For this reason, a full explanation regarding the technology was offered to the participants who were asked to report any discomfort. Another limitation is the cost of equipment; while cheaper alternatives to VR are available, the technology itself remains relatively expensive. Despite using a gender and socio-culturally neutral tone, the intervention might not be applicable to men from different sociodemographic backgrounds. This was reflected in the fact that a third of the participants did not agree that the intervention was suitable for men with different educational backgrounds. In addition, diseases such as varicocele, hydrocele, and spermatocele were not covered in E-MAT; therefore, it is possible to include these benign testicular diseases in future iterations of the E-MAT intervention.

From a methodological perspective, the generalizability of findings is compromised due to the small sample size. Of note, there is no gold standard for sample size calculation in feasibility studies and a 15-person sample size for feasibility and usability testing is regarded as appropriate (Orsmond and Cohn 2015). Moreover, participants were recruited using non-probability sampling, which hinders sample representativeness, increases the risk of self-selection bias, and compromises the generalizability of findings. As for data collection instruments, only a single item was used to measure the participants' overall satisfaction with the intervention. This could be improved by using other elements of satisfaction identified in a meta-analysis of the empirical evidence on customer satisfaction (Szymanski and Henard 2001). These include: expectations, disconfirmation of expectations, performance, affect, and equity. Moreover, Verhagan et al. (2011) introduced an integrated model of experiential value to assess user satisfaction with virtual worlds. Key elements of this model include: escapism (escaping reality); entertainment value (perception of the system as fun and pleasant); economic value (buyers' net gain from purchasing the system); and ease of use (navigating the system freely and effortlessly) (Verhagan et al. 2011).

In this paper, we discussed the development, feasibility, and usability of the E-MAT intervention, which was designed as an educational experience and delivered via a VR headset, controller, and over-ear headphones. The three levels of this intervention were aimed at familiarizing men with the normal testes and common testicular symptoms and disorders, highlighting the importance of feeling one's own testes, and increasing men's ability to differentiate between normal and abnormal testicular findings. The intervention also stressed the importance of early help seeking for testicular symptoms. The feasibility and usability of the intervention were established with 15 men who were satisfied with the intervention and perceived it as user-friendly and interactive and enjoyed its different elements including the voiceover, haptic feedback, and light humor.

The E-MAT intervention can be used as a public educational tool by making it available on public platforms that men can access at their own leisure. Examples include websites of national and international cancer organizations, organizations involved in health promotion, and high schools and universities. It is also important to disseminate the E-MAT intervention among men who are at risk for health inequities. This could be achieved by making the intervention available in settings frequented by these men, such as men's sheds, sports clubs, and youth organizations.

VR is increasingly gaining popularity among youths and the number of VR users is expected to increase by 147% between 2016 and 2021 (Mind Commerce 2016). The fast-paced growth of this technology has led to a significant reduction in the cost of access to VR headsets. Furthermore, it is possible to disperse the intervention as a traditional, non-VR experience that would run in a normal desktop environment. This format is best suited for those who do not have access to VR and those who suffer from VR sickness. From a research perspective, we recommend gathering more data regarding the key elements that explain the relative success of E-MAT to inform the design of new systems for related health topics such as sexually transmitted infections and prostate cancer. We also recommend testing the effectiveness of E-MAT and comparing it to other media such as audio-visual and/or written information without the interactive VR element.

Conflict of interest: None to declare

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Figure captions:

Fig1. The Preconscious Awareness to Action Framework (Saab et al. 2018b).

Fig2. The 3D models used to represent the testes in the first level of the intervention.

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