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The effect of health videogame with story immersion for childhood obesity prevention among Hong Kong Chinese children

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The Effect of a Health Videogame with Story Immersion for Childhood Obesity Prevention among Hong Kong Chinese Children

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DECLARATION

I hereby declare that this thesis represents my own work which has been conducted after registration for the degree of PhD at Hong Kong Baptist University, and has not been previously included in a thesis or a dissertation submitted to this or any other institution for a degree, diploma or other qualifications.

Signature: _____

Date: September 2015

ABSTRACT

Introduction: Video game is an emerging technology with potential to overcome many of the current barriers to behavior change. Video game playing is now woven into the fabric of children's life and has been developed to educate individuals in health-related areas. Story immersion refers to the experience of being fully absorbed within a story in the game and is a key factor that contributes to the mechanism of behavior change. "Escape from Diab (Diab)"is a health videogame designed to lower the risk of obesity and type 2 diabetes through behavior change components that were integrated into activities within the game storyline. This thesis was designed to investigate the effect of Diab for childhood obesity prevention among Hong Kong Chinese children.

Methods: A literature review was conducted. Subsequently, study one conducted the validation of the Physical Activity Questionnaire for Older Children (PAQ-C) with 469 Hong Kong Chinese children. Study two was a cross-sectional study to explore the associations of self-efficacy, motivation, preference with both self-reported and objective physical activity (PA) in 301 children. Study three consisted of two phases. Phase one conducted individual interviews with 34 Hong Kong Chinese children to gather their perceptions of Diab and to assess Diab's acceptability and applicability. Phase two examined the effect of playing nine episodes of Diab on children's health outcomes (i.e., motivation, self-efficacy, preference for diet and PA, and PA behavior) through a non-randomized intervention.

Results: The review demonstrated the effects of interventions by using health videogames on the psychological correlates. However, limited evidence is available to draw conclusions on the games' behavioral modification efficacy. In study one, good internal consistency and test-retest reliability suggest that the PAQ-C is an adequately reliable instrument for use among Chinese children. The significant moderate correlation between the PAQ-C score and accelerometer measured moderate-to-vigorous PA support the PAQ-C's acceptable validity. Study two revealed the important effects of self-efficacy and autonomous motivation in predicting PA. Differences were found between the prediction of self-reported PA and objective PA, which is likely due to self-reported error variance common to the PAQ-C and psychological correlates but not common to acclerometry. Study three indicated that Diab was perceived to be an immersive game by most of participating Hong Kong Chinese children. Four themes emerged from the interviews indicated that story immersion was a perceptible component and that Diab, developed for American children, was acceptable to the Hong Kong Chinese children. The pilot intervention study found short-term benefits after completing the game. However, the effects were not sustained at follow-up testing 8-10 weeks later.

Conclusion: The current thesis demonstrated the validity of PAQ-C and the important effects of self-efficacy and autonomous motivation in predicting PA, which could inform the development of efficacious interventions. Diab, a Health videogames with appealing characters and immersive stories, partially motivated children to improve their motivation, self-efficacy, and preference for diet and PA behaviors immediately after completing nine episodes of the game, however, the lasting effectiveness and mechanisms of change require more thorough investigation.

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LIST OF SYMBOLS

OR	Odds ratio
CI	Confidence interval
p	Probability value
F	Fisher's F ratio
n	Number of studies included, or number of participants
M	Mean value
SD	Standard deviation
SE	Standard error
B	Beta coefficient value
t	Student t test value
r	Correlation coefficient value
χ^2	Chi-square value
R^2	Coefficient of determination
ΔR^2	Change in the coefficient of determination
α	Cronbach alpha coefficient
d	Cohen's standardized difference

LIST OF ABBREVIATIONS

PA	Physical activity
MVPA	Moderate to vigorous physical activity
G4H	Games for health
AVG	Active video games
Diab	Escape from Diab
SDT	Self-determination theory
BNT	Basic needs theory
SCT	Self-cognitive theory
RCT	Randomized controlled trial
PE	Physical education
PAQ-C	Physical activity questionnaire for older children
SDNT	Self-care deficit nursing theory
ELM	Elaboration likelihood model
DDR	Dance Dance Revolution
MT	Maintenance theory
BIT	Behavioral inoculation theory
BMI	Body mass index
CITC	Corrected item total correlation
CFA	Confirmatory factor analysis
CFI	Comparative-fit index
TLI	Tucker-Lewis index

RMSEA	Root-mean-square error of approximation
SRMR	Standardized root mean square residual
MANOVA	Multivariate analysis of variance
SocD	Social desirability
EMI	English medium instruction
FVW	Fruit, vegetable, and water
ANCOVA	Analysis of covariance
RM ANCOVA	Repeated measures analysis of covariance
LOCF	Last observation carried forward

CHAPTER 1 INTRODUCTION

Background of the Study

Childhood obesity prevalence and correlates

The prevalence of child and adolescent obesity has increased substantially over the last few decades throughout both developed and developing countries (Adair, 2008; Song, Wang, Ma, & Wang, 2013; Wang, McPherson, Marsh, Gortmaker, & Brown, 2011). Obesity prevalence among 11- to 15-year-old USA children increased from 13.5% in 1995 to 17.6% in 2007 (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010). In 2011-2012, 31.2% and 16.9% of US children aged 2-19 years were overweight and obese (Ogden, Carroll, Kit, & Flegal, 2014; Skinner & Skelton, 2014). According to the data from six Chinese National Surveys on Students Constitution and Health (CNSSCH) from 1985 to 2010, the standardized prevalence of obesity in Chinese children increased rapidly, from 0.2% in 1985 to 8.1% in 2010 (Song et al., 2013). A report from the Student Health Service in Hong Kong Department of Health implicated that the obesity rate among primary school students in the 2011-2012 school year was 20.9%, which was 4.5% higher than 16.4% in the 1997-1998 school year, reflecting the worsening trend of childhood obesity epidemic in recent years (Hong Kong Department of Health, 2013). The increased level of childhood obesity in Hong Kong is approaching that of Western affluent countries, and is much higher than that in Mainland China.

Obesity not only increases an individual's risk of death from numerous causes (Flegal, Graubard, Williamson, & Gail, 2007; Orpana et al., 2009), it also induces psychosocial and economic consequences (Wang & Dietz, 2002). Childhood obesity

leads to the short and long-term health risks, including cardiovascular risk factors and metabolic syndrome, chronic effects on self-esteem, body image, and the persistence of obesity into adulthood (Must & Strauss, 1999; Reilly et al., 2003). Increased cardiovascular risk factor levels and several other adverse consequences can result in increased morbidity in early life as well as in later adulthood (Mossberg, 1989; Must, Jacques, Dallal, Bajema, & Dietz, 1992; Reilly, 2005). Kong and colleagues (2010) reviewed the clinical evidence in medical consequence of obesity in Hong Kong Chinese youth and found that overweight in children was associated with metabolic syndrome, impaired arterial endothelial function, increased carotid intimal medial thickness, and elevated inflammatory marker. Psycho-social discrimination on obese children and adolescents can bring about social isolation with accompanying their psychological problems (Dietz, 1998). Moreover, twenty five to 50% of individuals who are obese in adolescence remain obese in their adulthood (Garn, 1985).

Fat is gradually deposited from energy imbalance as a combination of the two: excess energy intake and low energy expenditure (Maziak, Ward, & Stockton, 2008). Modern lifestyles (passive overeating, inactivity and/or sociocultural economic influence) in an obesogenic environment lead to an increased prevalence of obesity among children (Egger & Dixon, 2009). Energy dense diets and lack of physical activity (PA) are the dominant determinants of child obesity and the major culprits in the evolving child obesity epidemic (Agras & Mascola, 2005; Veugelers & Fitzgerald, 2005). High prevalence of obesity in Hong Kong may be partly attributed to dietary habits and lifestyles similar between Hong Kong and West (Wong et al., 2005). Popular foods among children across the global have shifted to more high-energy-dense food, including

breads, potatoes, sweet cereals, fast foods and soft drinks (Chopra, Galbraith, & Darnton-Hill, 2002). In Hong Kong, diet has changed substantially during the last two decades. The traditional Chinese diet which previously consisted predominantly of rice and beans, has shifted to a Westernized diet which is high in fat, added sugars, and snacks (Woo, Cheung, Ho, Sham, & Lam, 2007). Among 6-7 years old students, childhood overweight was positively associated with higher energy consumption (odd ratio (OR): 2.62, 95% confidential interval (CI): 1.20-5.74) (Hui, Nelson, Yu, Li, & Fok, 2003). Meanwhile, current lifestyles and environments likely discourage regular PA and encourage sedentary behaviors (Ha, Abbott, Macdonald, & Pang, 2009). Hong Kong primary school students may have the most inactive children in the world. Only one quarter of all children were classified as being "active" (Adab & Macfarlane, 1998). Except physical education class, only 22.6% of boys and 14.5% of girls were reported to engage in leisure exercise at least twice a week. Over half of the students did not do regular exercise except during physical education classes (So et al., 2010). The summary annual report 2011-2012 of Hong Kong Leisure and Culture Service Department revealed only 8.3% of Hong Kong children (7-12 years old) were active (participating in moderate-to-vigorous PA (MVPA) for 60 accumulated min every day for 7 days), while 20.7% were extremely inactive (participating in 60 min MVPA every day for less than 1 day/week) (Leisure and Cultural Services Department of Hong Kong, 2012). Although young Hong Kong children get reasonable amounts, PA levels decline with age throughout childhood (Mak & Day, 2010). In light of this severe situation, interventions to help children and adolescents improve their diet and increase overall daily activity should be implemented.

Interventions for childhood obesity

Energy from food intake and spent on activity are the primary discretionary elements of energy balance. Many laboratorial and clinical epidemiological studies have indicated that low-energy dense diets (e.g., water and fiber-rich fruit, vegetables and grains) were positively associated with lower energy intake, better diet quality, and subsequent body weight control (Rolls, Drewnowski, & Ledikwe, 2005). Solely promoting water consumption in a combined environment and educational intervention showed the effectiveness in preventing overweight among primary school children (Muckelbauer et al., 2009). Reducing sedentary behaviors (e.g. television viewing and computer using) and increasing PA also may lower body mass index (BMI) and prevent obesity in young children (Epstein et al., 2008). Consuming more fruit and vegetables to reduce caloric intake (Epstein et al., 2001), drinking more water to lower sweetened beverage intake (Muckelbauer et al., 2009), reducing sedentary behaviors and engaging in more PA may result in improved energy balance (Biddle, Gorely, & Stensel, 2004). Interventions on both sides of energy balance seems more likely to be effective than working only on one side (De Bourdeaudhuij et al., 2011). Despite the heterogeneity of studies in one review were with inconsistent findings, overall, the interventions focused both on diet and PA may help to prevent children from becoming overweight in the short term (Waters et al., 2011).

Numerous obesity-related interventions have been developed and implemented in the past decade in school, family and community settings. With the majority of the school-based interventions having positive effects on children's PA level, school was the most effective avenue for delivery of programs (Eisenmann et al., 2008; Summerbell et

al., 2005). An econometric analysis of one school-based obesity prevention program, *Planet Health,* found it to be cost-effective (Wang, Yang, Lowry, & Wechsler, 2003). Children spend many hours at school, physical education (PE), and education classes which truly become important channels for delivering the behavior change interventions (Sobol-Goldberg, Rabinowitz, & Gross, 2013). School-based interventions also have the potential for establishing healthy diet and exercise patterns to reduce chronic disease risk, which may persist into adulthood.

Traditional school-based obesity prevention interventions have been typically delivered via education approaches which no longer satisfy the needs of such a large population of overweight and obese children (Hillier, 2008). Several limitations were pointed out for the body of school-based studies. Few of them have documented causal links between environment, motivation and weight status (Sallis & Glanz, 2006). Technologies are now becoming rapidly integrated into people's lives. Children spend much of their time with the various technological platforms (internet, phone, and video games etc.). Technology has made it possible for individuals to engage in sophisticated, simulated entertainments, education, and social interaction environments. Researchers are increasingly looking to technology to promote healthy living through school children's cognitive self-regulation, motivation and competence to increase their healthful eating and PA behaviors through these new technologies (Contento, Koch, Lee, Sauberli, & Calabrese-Barton, 2007).

Cell phones and Web sites have become allies in the fight against childhood overweight (Baer, Cho, Walmer, Bain, & Bates, 2013; Fjeldsoe, Marshall, & Miller, 2009). Feedback from a counselor through using the mobile phones and internet

regarding goals, progress, and results have the ability to encourage, motivate and assist patients to have more confidence in completing a weight-loss program (Hurling et al., 2007). Although most of these mass media-based interventions successfully enhanced individual's awareness and knowledge, needs to be demonstrated their effectiveness is still required in children and adolescent (Marcus et al., 2006). PA choice is largely dictated by the level of enjoyment (Epstein, Beecher, Graf, & Roemmich, 2007) and "fun" is the most frequently reported reason for children's participation in PA (Borra, Schwartz, Spain, & Natchipolsky, 1995). Video games for health offer some promises in enjoyment while engaging children in behavior change programming.

Health videogames-based intervention for the childhood obesity

"Video game" refers to the game played on a digital device. It encompasses a wide range of games played through different channels, e.g., over the Internet on personal computers, or on dedicated game consoles, handheld units on smart phones or tablets. Playing video games has become a popular free-time activity among youth (Nippold, Duthie, & Larsen, 2005). Three to five types of game devices (e.g. large screen/TV-based games, small handheld game devices and active game devices) were common among primary school children in Hong Kong, with approximately 40% of the respondents being weekly and 18% being daily users (Lui, Szeto, & Jones, 2011).

Marsh (2011, p.63) defines serious games as: "*Serious games are digital games, simulations, virtual environments and mixed reality/media that provide opportunities to engage in activities through responsive narrative/story, gameplay or encounters to inform, influence, for well-being, and/or experience to convey meaning*". Games and their outcomes are categorized based on the primary function of the games, that is, whether the

initial purpose of game was for entertainment, for learning or for a serious objective. Compared to games-based learning, serious games have been developed for the broader purpose (e.g., training and behavior change in education, healthcare, business, and marketing) (Sawyer & Smith, 2008). Digital commercial games were primarily developed for fun entertainment, while the main aims of serious games are learning, education, and behavior change (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012). Sometimes, learning and serious games are used synonymously. In the last few years, a serious game movement and perspective has emerged regarding the use of both computer and video games for non-entertainment, learning and education purposes. "Fish 'n' Steps" (Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006; Northcutt, 2012), "Lunch Crunch" (Northcutt, 2012), "Dance Dance Revolution" (Andrews, 2007), and "Eyetoy: Kinetic Combat" (Thin, Hansen, & McEachen, 2011) are all serious video games with commercial availability. "Games for health (G4H)" are serious video games that focus on health (Baranowski, Buday, Thompson, & Baranowski, 2008) and target disease prevention (Baranowski, Baranowski, Cullen, Marsh, Islam, Zakeri, Honess-Morreale, et al., 2003) and management (Brown et al., 1997). Recently, health games have become a mass phenomenon, and now it is possible to apply them to enhance cognitive skills or healthy behaviros.

Much of the early computer games research focused on the negative impact of playing games, especially their negative psychological impact on violence, aggression (Anderson & Bushman, 2001), sedentary time and body fatness among children and youth (Marshall, Biddle, Gorely, Cameron, & Murdey, 2004; Punamäki, Wallenius, Nygård, Saarni, & Rimpelä, 2007). Even this early focus on negative impacts, currently,

there has also been mounting interest in the positive effects of playing games. Some have proposed that playing newly designed active computer- and video- console games (also called "exergaming") and serious health video games may convert the traditional sedentary activity and contribute to young people's PA levels and energy expenditure during their leisure time (Daley, 2009). Using video games, such as these to promote behavior change, provides an opportunity to capitalize on children's attention and enjoyment. Videogames have been found to induce positive health behavior changes among children, such as increased PA (Baranowski et al., 2008). Numerous studies have been implemented and provided some scientific evaluation and evidence of game-based approaches on the positive effects in health-related behavior changes (Baranowski et al., 2008; Kato, Cole, Bradlyn, & Pollock, 2008). A recent review has indicated that by comparison with conventional instruction methods, serious games were found to be effective in terms of learning (d = .29, p < .01) and retention (d = .36, p < .01), but they were no more motivating (d = .26, p > .05). In this review, additional moderator analysis on the learning effects indicated that, compared to those taught with conventional instruction methods, learners in serious games could learned more with the game supplemented with other instruction methods, with involving multiple training sessions, with playing worked in groups (Wouters, Van Nimwegen, Van Oostendorp, & Van Der Spek, 2013).

Active video games (AVGs) refer to the video games that require PA beyond that of traditional hand-controlled games (Mears & Hansen, 2009), which is a new generation of video games and an important branch of games used in obesity-related interventions. AVGs become a meaningful channel which can be contributed to the children's daily PA

and provide more options for players (such as tennis, yoga, dancing, pingpang and golf). Some research using AVG has shown promising evidence with which to promote PA in children (Biddiss & Irwin, 2010). However, evidence from interventional studies to date is mixed on whether AVGs can engage children and adolescent in PA levels that are beneficial for public health outcomes. AVGs may also have the possibility of physiological events and Wii- related injuries (such as Wii knee) due to prolonged or overly aggressive play (Oka, Suzuki, & Inoue, 2008). All these evidence indicates that it is essential that children should establish proper perceptions of AVGs. Additionally, the most AVGs only target PA as the intervention component without diet. As noted, targeting multiple behaviors modification may provide significant health benefits. Further research conducting interventions targeting PA and nutrition simultaneously via health videogames is required.

Health videogame with story immersion for childhood obesity intervention

Insufficient physical inactivity and poor dietary habits are difficult to change, especially for children and adolescents. Although it is assumed that an individual's intention to change could be a best direct predictor of actual change in most social cognitive theories (Schwarzer, 2008), people often do not behave with their intentions accordingly. Several reasons are attributed to this discrepancy between intention and behavior, e.g., unforeseen barriers, giving in to temptation. Thus, methods are needed to supply and stimulate intention maximally by other, more proximal factors (Schwarzer, 2008). Mediators and/or moderators are needed to explain the process from intention to behavior. In most cases, 30% or less of the variability in PA behaviors can be explained by behavioral or psychosocial variables (Baranowski, Anderson, & Carmack, 1998).

However, the effects and pathways of the mediating variables in these theories were not explored sufficiently. Mediating variables are in a cause-effect chain along the pathway from an intervention to an outcome. The interventions act on the mediators, and the mediators effect the behavior outcomes. The behavioral change results from programs or interventions are followed to changes in the mediating variables (Baranowski, Cullen, Nicklas, Thompson, & Baranowski, 2003). It is more likely that the interventions are effective if the association between mediating variables and the targeted behaviors are strong and if these mediating variables could be manipulated followed in desired directions (Baranowski, Lin, Wetter, Resnicow, & Hearn, 1997).

In recent years, there has been an increasingly researches applying video games as a channel to modify the population's behaviors. However, little is known about the pathway how effective mediation of behavior change from video games and insufficient information is provided on how the mediators (behavior) can be maximally effective to design behavior-change procedures under various circumstances. A model of mediation of diet and PA behavior change using video games has been proposed by Baranowski et al. (2011), which is a framework for understanding how interventions work to promote change in dietary and PA behaviors and providing the information on designing interventions (presented in *Figure* 1.1).

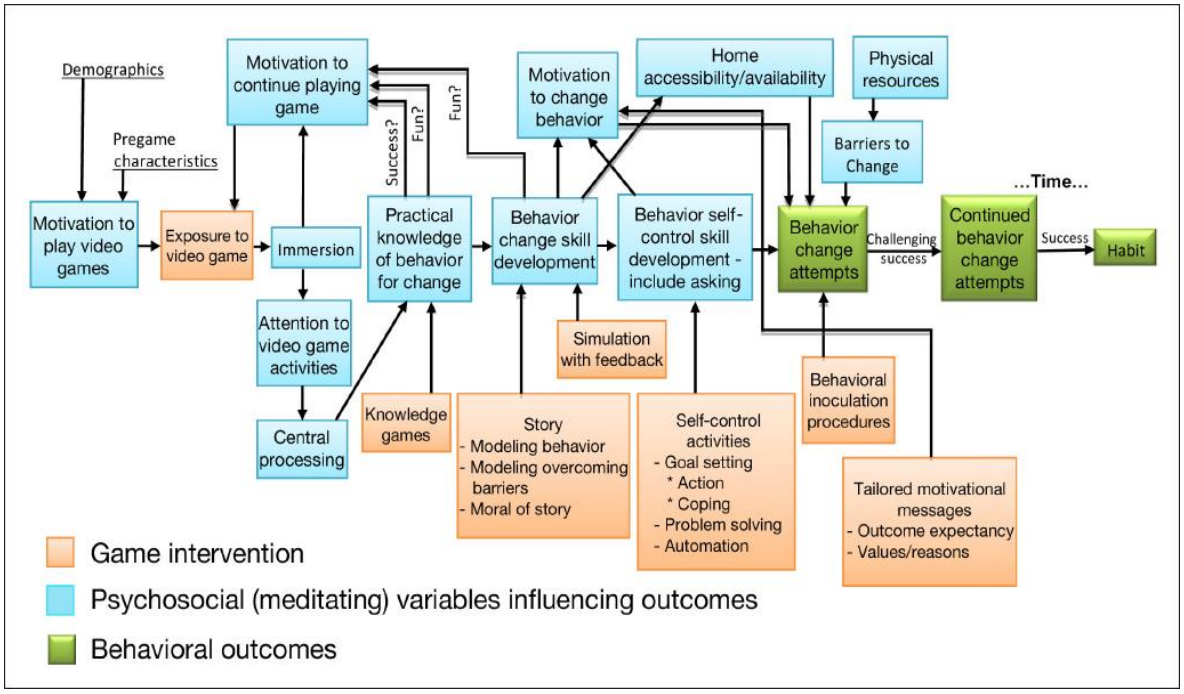

Figure 1.1. Model of how video games with component change procedures influence mediators to change behaviors.

Reprinted from 'Behavioral science in video games for children's diet and physical activity change: key research needs', by T. Baranowski, J. Baranowski, D. Thompson, and R. Buday, 2011, *Journal of diabetes science and technology, 5*(2), p. 230. Copyright 2011 by Diabetes Techonogy Society.

This model was developed based on construct perception from four theories: self-determination, transportation, elaboration likelihood, and social cognitive theories. Within this model, the orange components represent the interventions, the psychosocial influences was shown in blue, and the behavioral outcomes appear in green (Baranowski, Baranowski, Thompson, & Buday, 2011). From the model of how video games with component change procedures influence mediators to change behaviors, immersion is one of the front end components of the effect chain, which acts on the motivation to continue game directly. What is more, the motivation to continue game is the essential element for the maintenance of the effect of video games. Immersion is a process in which people engage into the story world and are changed by the travel journey (Gerrig, 1993).

Coomans and Timmermans describe immersion as "*a feeling of being deeply engaged where people enter a make-believe world as if it is real*" (Coomans & Timmermans, 1997, p.6). It is generally thought of immersion to describe the audience's experience in a narrative or dramatic setting. Presence is the term to describe the gaming experience in an entertainment context. This term originates from virtual reality studies and refers to the feeling of being there (Heeter, 1992). Cairns et al. (2006) argued that presence in a virtual reality context corresponds to the extent of player's immersion in a gaming context processes during game playing.

However, there are few video games that have integrated immersion as a characteristic, especially for children and adolescent. "Escape from Diab" (hereinafter referred to as "Diab") is a health game with immersion integration which has recently been developed by Archimage (Houston, TX). Diab tells the story about Deejay, an athletic boy who accidentally falls into Diab, a nightmarish world where he and his newly found friends must escape by adopting a healthier lifestyle (Baranowski, Baranowski, Thompson, Buday, et al., 2011). It was designed to lower the risk of type 2 diabetes and obesity, by improving children's diet and PA behaviors (Thompson, Thompson, Baranowski, & Evans, 2010). Videogame immersion has received scant empirical investigation in obesity research. Lu and colleagues (2012) carried out an intervention study to test whether increased levels of immersion relate to more positive health outcomes. It was among the first studies to analyze story immersion's role in health video games among children. The author found the importance of effectively embedding characters with similar phenotypic features to the target population narratives when motivating children to adopt obesity prevention behaviors in interactive health videogame.

Beltran et al. (2013) found that Diab was also considered acceptable by pediatric cancer patients and survivors. These initial findings seem to support the use of Diab to improve the motivation of children and adolescents. The video game creates a virtual environment, which can help the user feel become immersed and consequently experience a high degree of control and as a result impact on virtual environment. Thus, the reason for selecting the game Diab is to explore the effect of health videogame with story immersion on children's health outcomes.

Theoretical Framework of the Study

Over the past three decades, numbers of research reports and review articles published have been reflecting the desire to better consider, explore and understand the determinants of health–related action (Nutbeam, 2000). According to the established evidence, interventions based on psychosocial models have been demonstrated to be more effective, and can help researchers to identify pathways from intervention to behavioral outcomes. Various psychosocial models have been employed in behavioral science to understand PA behavior and to provide the conceptual and empirical knowledge base for designing the activity promoting programs.

Self-determination theory

Self-determination theory (SDT) uses traditional empirical methods and highlights the significance and importance of human's inner involvement and resources for behavioral self-control, regulation and personality development (Ryan, Kuhl, & Deci, 1997). SDT is an approach to human motivation by nature a meta-theory, and one mini theory is Basic Needs Theory (BNT). BNT is distinct based that human's behaviors

which facilitate internalization and internalization should be satisfied on one's needs from environment. Inductively, using empirical processes, three such fundamental needs have been identified: the needs for autonomy, competence, and relatedness, which maximize optimal functioning of propensities for integration and utilization and are essential for personal well-being and constructive social establishment and development (Ryan & Deci, 2000). Autonomy refers to being the perceived origin or source of individual's own behavior. An expression of the self is considered to be autonomous and individual's behavior is valued by the power to make their own choices. Competence indicates the feeling of effectiveness on the association between an individual's interaction and the social environment and that represents the capacity of exemplifying confidence in experiencing opportunities and the ability of human to effectively perform the behavior. Relatedness refers to having a sense of belonging and connection to lives of others in a social environment, which is reflected for individual to feel integral to others (Deci & Ryan, 2002). Relatedness enables human to feel authentic connections with others and also helps to understand how various social forces and interpersonal environments interact. Individuals cannot thrive without satisfying the specifying psychological needs as essential nutriments.

Motivation is the concerns related to all aspects of activation and intention on energy, direction and persistence. SDT focuses on offering a more differentiated approach to motivation by exhibiting which kind of motivation at different time points. By considering the perceived forces and origins that encourage a person to act, SDT has been proposed to identify several distinct types of motivation between self-motivation and external regulation, each of which has different influence and consequences for learning,

performance, well-being, and all other personal behaviors (Ryan & Deci, 2000). On the basis of the theoretical tenets of SDT, these different types of self-regulation are hypothesized to form a continuum ranging from none, low to high levels of self-regulations and can be categorized as amotivation, extrinsic motivation, and intrinsic motivation.

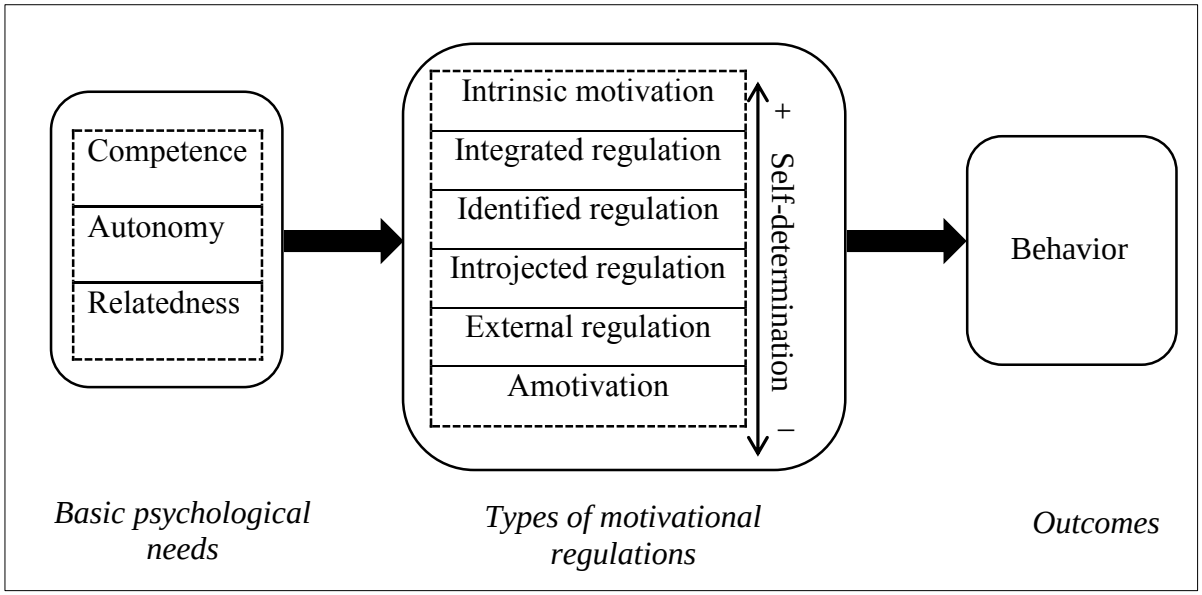

Figure 1.2. Presentation of motivational sequence of the self-determination theory

Reprinted from 'Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being', by R. M. Ryan, and E. L. Deci, 2000, American psychologist, 55(1), p. 72. Copyright 2000 by the American Psychological Association, Inc.

As shown in *Figure* 1.2, at the bottom of the self-determination ranging is amotivation, the statement with lack of the intentionality and personal causation. When people are being amotivated, they act without intention, simply go through the motions or do not act all. Amotivation is a state of non-valuing an activity, not feeling enough competence and relatedness to do it or not expect desirable outcomes to complete it. On the continuum, extrinsically motivated behaviors locate between amotivation and intrinsic motivation. Theory and research have suggested that there are different types of

extrinsically behavioral motivations and these motivations are with different extents of representing self-determined internal versus controlled responding (Ryan & Connell, 1989). Deci and Ryan (1985) identified four types of extrinsic motivation: external, introjected, identified and integrated forms of regulation. External regulation refers to the behavior in order to achieve some separable outcome. People with external regulation perform the activity from the external locus of initiation (e.g., for reinforcement such as gaining rewards or avoiding punishment). Introjected regulation involves internalized rules or demands somewhat, that pressure one to act sustained with promised rewards or threatened punishment (e.g., for avoiding external source of disapproval, or gaining externally referenced approval). Identified regulation occurs when the person has accepted the regulatory process. In this phase, the individual has realized and identified the value of behavior. Identified regulation is present for person come up to values such as learning new skills, internally referenced contingency. The most advanced developmentally form of extrinsic motivation is integrated regulation in which the regulatory process is fully integrated with individual's coherent sense of self. The individual's behaviors are fully incorporated into the behavioral repertoire that satisfy their psychological needs (Deci, Vallerand, Pelletier, & Ryan, 1991). At the top of the continuum is the classic state of intrinsic motivation, which refers to perform an activity for individual's inherent satisfactions. An activity is considered highly autonomous with the enjoyment of doing it, such as for pleasure, fun, other than requiring discernible reinforcement or reward. Intrinsic motivation exists within individuals in the relation between individual self and activities (Ryan & Deci, 2000). Intrinsic motivation is the core type of motivation underlying exercise and sport and represents the prototypic

instance of self-determination (Frederick & Ryan, 1995).

Based on the concept of internalization, the classification of extrinsic motivation described above was established to detail the contextual factors which may either promote or hinder the action of internalization and integration of regulation for behaviors. It proposes the development process from extrinsic to intrinsic motivation. SDT also proposed three categories of motivation that present on a continuum of self-determination: autonomous motivation, controlled regulation, and amotivation. SDT posits that autonomous motivation reflects a sense of personal volition and originate from internal perceived locus of casualty, whereas, controlled motivation reflects external demands which are originating from an external perceived locus of causality (Deci & Ryan, 2002). Identified regulation, integrated regulation, and intrinsic motivation are considered autonomous forms of motivation since they present highest internal quality of regulation. Alternatively, introjected and external regulations are considered controlled motivation since they present the intermediate and lower ends of quality continuum.

Self-efficacy theory

Social cognitive theory, proposed by Bandura (Bandura, 1986), posits that human functioning results from a dynamic interplay among personal, behavioral, and environment factors in a triadic reciprocality. Specific constructs in cognitive or personal factors include perceived self-efficacy, expected outcome, and coping. In SCT, one of the most important cognitive constructs within individual is perceived self-efficacy. Self-efficacy refers to perceived capabilities for learning, performing, or completing actions at designed levels. Self-efficacy is a necessary component of behavior change since it indicates an individual's belief about his or her ability to be successful in initiating and

maintaining a specific activity. A person with self-efficacy has the ability to handle behavior change.

Bandura (1997) postulated that people could acquire information from four sources (namely actual performance, vicarious experience, forms of social persuasion, and physiological indexes) to gauge their self-efficacy. Individual's actual performance could provide the most reliable and practical information and could be interpreted as successful to raise self-efficacy. Individual can acquire much information on knowledge of how others perform to improve their capabilities. Similarity to others is considered a cue for gauging individual's self-efficacy. Observing the success and learning from similar others could motivate them to try the task and raise observer's self-efficacy (Schunk, 1995). Social persuasions (e.g., I know you can do it well) also provide an important part in development of an individual's self-efficacy. Individual also can acquire self-efficacy information from physiological states. Strong physiological and emotional reactions when having a task or facing a challenge may bring an anticipated success or failure. To raise self-efficacy, negative emotional states should be reduced and physical and emotional well-being should be improved. Individual's judgement of self-efficacy is influenced by the recollection, integration and interpretation of information.

Theoretically, people with high self-efficacy can complete the tasks, overcome the challenges, heighten their efforts in face of failure, and sustain the commitment to positive behaviors. Conversely, people with low self-efficacy may think that things are more difficulty than they really are, which may bring them anxiety, stress, depression, and a negative vision to the situation. Self-efficacy is predicted to enhance individual's accomplishment and wellbeing (Karademas, 2006).

Application of SDT and self-efficacy in health videogames

SDT has been used as a theoretical framework in the design of traditional computer games intended to improve learning (Jovanovic, Starcevic, Stavljanin, & Minovic, 2008; Tüzün, Yılmaz-Soylu, Karakuş, İnal, & Kızılkaya, 2009), and to promote health behavior change through increased intrinsic motivation. A greater sense of autonomy predict motivation for continued play of computer game and increases enjoyment of the game (Ryan, Rigby, & Przybylski, 2006). Self-determination theory focuses on factors that either facilitate or undermine motivation, both the intrinsic and extrinsic (Ryan & Deci, 2000).

A study conducted by Teixeira and colleagues (2006) supported the notion that initial focus on diet is associated with short-term weight loss, while change in exercise-related motivational factors, with a special emphasis on intrinsic sources of motivation (e.g., interest and enjoyment in exercise), play a more important role in longer term weight management. The study highlighted the importance of cognitive processes during weight control. Williams et al. (1996) conducted a study specifically designed to examine the effects of motivational factors during a weight control program. The findings indicated that having a stronger autonomy orientation and maintaining autonomous reasons for participation through the program (as opposed to controlling motivations) were predictors of better weight loss. A high sense of autonomy is a hallmark of behaviors that are intrinsically regulated (Ryan & Deci, 2000). Intrinsic motivation is generally driven by characteristics such as novelty, challenge, and aesthetic value (Ferrer-Caja & Weiss, 2000).

Higher self-efficacy has been found to be one of the strongest determinants of

behavior change and maintenance (Sallis, Pinski, Grossman, Patterson, & Nader, 1988). Self-efficacy can be enhanced through experimental manipulation and that this enhancement is positively related to subsequent health behavior change. The positive effects of video games on self-efficacy have been observed in various aspects, for example, cancer treatment adherence (Kato et al., 2008), safer sex negotiation (Thomas, Cahill, & Santilli, 1997), juvenile diabetes (Brown et al., 1997), asthma self-management, smoking prevention and other managements of chronic pediatric diseases (Lieberman, 2001). Staiano and colleagues (2013) conducted an exergame intervention for weight loss and psychological improvement among adolescents. The study found that cooperative exergame players significantly lost more weight and increased on self-efficacy compared to the control group. Video games with appealing role-model characters offer unique advantage for delivering health promotion message to children and adolescents (Klimmt & Hartmann, 2006). When playing, video games present scenarios that making decisions and practicing self-care skills and then depict realistic consequences in response, which affect player's important beliefs and practices among young children (Kato, 2010; Lieberman, 2013).

Story narratives may promote continued play, and increased enjoyment among children. Behavioral change games with embedding narratives of immersive qualities could help to promote the development of intrinsic motivation, to complete the game, even, to adopt the behavior promoted in the game and to maintain the behaviors afterwards (Lee, Park, & Jin, 2006). Story immersion refers to a mechanism through which a narrative influences players' cognition, affect, psychological behavioral complement, and, potentially, subsequent health behavior (Pillay, 2002).

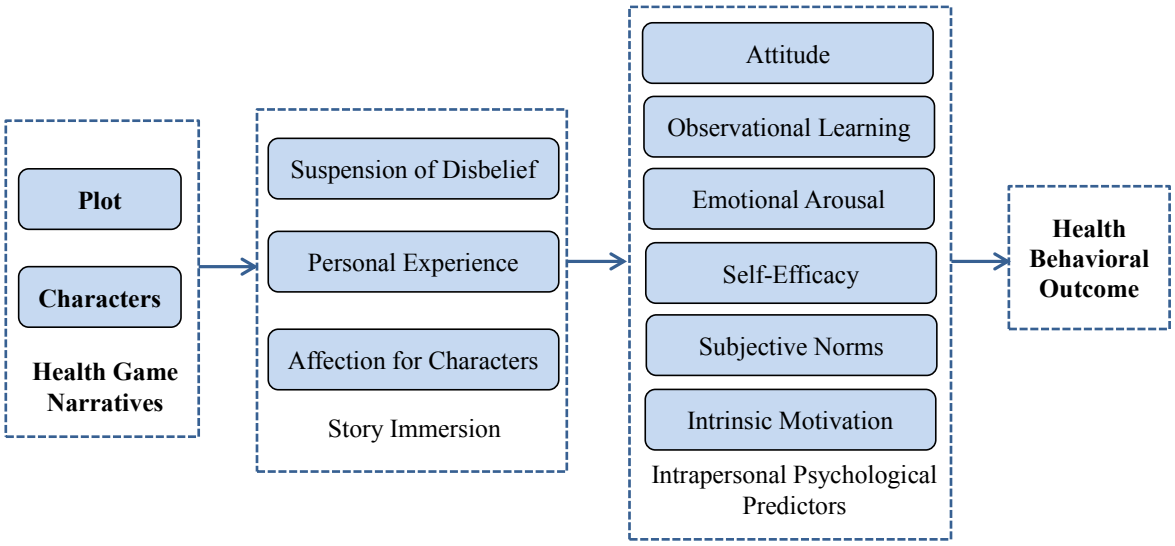

Figure 1.3. The hypothetical framework for the mechanisms of story immersion of health games.

Reprinted from 'Story immersion of videogames for youth health promotion: A review of literature', by A. S. Lu, T. Baranowski, D. Thompson, and R. Buday, 2012, *Games for Health: Research, Development, and Clinical Applications, 1*(3), p. 202. Copyright 2012 by Mary Ann Liebert, Inc.

Children and adults have played games since before written history, and this suggests that playing games meets some of enduring psychological needs. The players can get achieve a sense of fun and entertainment, which satisfies their need for autonomy, connectedness and control through games. Some researchers stated that games have an character of fun and an element of intrinsic motivation, thereby potentially enhancing behavior change through the increased motivation (Ryan et al., 2006). With technological advancements, video games have been revolutionized and been well integrated with immersive stories. Immersion is believed to be a component of intrinsic motivation and self-efficacy. A hypothetical model has been stated by Lu et al. (2012) to illustrate the perspectives and speculations related to behaviors through enhancing player's intrinsic motivation and other learning (shown in *Figure* 1.3). Engaging videogame narratives may influence players through the following three ways. First, immersion can help them

with the suspension of disbelief and reduction of counterarguments; second, narrative experience can take record in audience member's memory and become a personal experience when coming across the real events; third, the means of immersion's influence can be through the creation of deep affection for a narrative's protagonists (Green, Garst, & Brock, 2004). Subsequently, the individual psychological constructs (i.e., attitude, observational learning, emotional arousal, self-efficacy, subjective norms, and intrinsic motivation) may go through changes due to these three ways. The interpersonal psychological predictors take effects on health behavioral outcomes as consequence.

Based on the theories and literature above, a well-crafted immersive story embedded in the health videogame may be especially suitable for health behavior change. Diab is one such newly developed G4H, which will be applied in the proposed study to examine its effects on psychological and behavioral predictors.

Statement of Problem

The prevalence of childhood overweight and obesity in Hong Kong has become higher over the past few years. Primary school children have more serious overfat problems than secondary school children (Chan, 2008). It is reported that children's PA level starts to decline after 9 years old and significant reduction occurs at 12 years old. The finding that being obese as a child at 10 years of age increases the risk of being an adult suggests that the age at 10 years old is a critical period for promoting healthy diet and PA to prevent child and adult obesity (Whitaker, Wright, Pepe, Seidel, & Dietz, 1997). Therefore, the effective prevention of overweight and obesity in Hong Kong

primary school children is imperative.

Despite various obesity interventions in Hong Kong had been conducted, the findings were not encouraging (Fu, Guo, & Zang, 2012). With the technological development, academic interest in using G4H for childhood obesity prevention has increased and positive outcomes have been observed in Western pediatric population (Lu, Kharrazi, Gharghabi, & Thompson, 2013). However, there is a paucity of study by using G4H among Hong Kong Chinese children.

In the mechanisms of G4H on health outcomes, story immersion is an important mechanism through which players could be absorbed in the game and be influenced on their cognition, attitude, affect, and potentially health behaviors. Theoretically, story immersion could complement behavioral change theories (Schneider, 2013). However, the contribution of story immersion is understudied in the field research. To our knowledge, there is no study have examined the effectiveness of health videogames with story immersion during school on children's behavior modification in Hong Kong. Diab is a commercial G4H originally developed for American children with appealing characters and immersive stories. It is still unknown whether the stories in Diab could be perceived by Hong Kong Chinese children and, in turn take effect on obesity-related outcomes.

Study purpose

The study aimed to deliver a school-based health videogame intervention to multiple targets (PA and diet aspects) in Hong Kong Chinese children by using Diab incorporating

the fundamental tenets of self-determination and self-efficacy theory and evaluate its effect on obesity-related health outcomes.

Significance of the Study

Rates of childhood overweight and obesity have increased 45% in the last decade and three-fold since 1980, which pose significant health problems (Centers for Disease Control and Prevention, 2010). Children who are physically active and have the healthy dietary behaviors are at lower risk for the development of obesity. Therefore, accessible and effective strategies to encourage voluntary participation in daily PA and the development of healthy dietary habits are needed (Baranowski et al., 2008). However, to date, many obesity interventions have achieved little or moderate success, especially among the less motivated population (Baranowski, Anderson, & Carmack, 1998). In addition, enforcing participation in PA and improving dietary behaviors are resource intensive, and the long-term success of these interventions remains unknown (Connelly, Duaso, & Butler, 2007).

Today's children and adolescents have had extensive exposure to digital devices. Video games are a part of their digital experience and these games have reached a large and diverse audience, suggesting games can attract and maintain attention, which is a key component for effective behavior change (Bandura, 1986). As the evidence suggests, targeting multiple behaviors for change may provide significant health benefits (Driskell, Dyment, Mauriello, Castle, & Sherman, 2008). However, existing studies, employing exergames, AVGs, or other video games, have been mainly aimed at diet or PA separately. Video games rare encompass both diet and PA simultaneously. The proposed intervention

video game Diab is able to contribute both PA and nutrition components to the field. Most importantly, video games are able to encompass and capture the player's full attention, as introduced previously this is termed immersion, and is believed to be a component of intrinsic motivation and self-efficacy (Ryan et al., 2006). The findings of this study have the potential to demonstrate whether a health videogame with integration of immersive story will have effect on increasing the children's motivation and self-efficacy to modify diet and PA behaviors. The results will contribute to existing health videogame, behavior modification literature, and may provide support to the mechanisms through which diet and PA behaviors could be modified. Moreover, the findings of the proposed study provide practical guideline with which to inform the design of future health videogames based PA and diet interventions for Chinese children. Finally, the proposed study aims to explore the feasibility of Diab in Chinese children and adolescent and whether this can serve as a prototype for technology-based interventions for the treatment of childhood obesity in China.

Research Questions

The study intends to focus on addressing the following research questions:

1) In the field, what are the effects of video games-based intervention studies on children's obesity–related outcomes?

2) What are the associations among psychological correlates (i.e., motivation, self-efficacy and preference) and PA behaviors? Do these indicators predict the children's PA levels?

3) Whether Diab, a health videogame from Western culture, is acceptable and applicable to Hong Kong children?

4) Whether the intervention by using Diab has the positive effects on children's psychological correlates and subsequent behavioral outcomes?

5) Whether the high story immersion in children's response to exposure to Diab will engender a more beneficial effect?

6) As a high-risk group, whether overweight children will be more motivated in the intervention and therefore more likely to benefit from the treatment than their healthy weight peers?

Delimitations

1) The proposed study adopts a health videogame with story immersion, named "Escape from Diab". The other AVGs and non-AVGs will not be applied.

2) SDT and self-efficacy theory are integrated into the study and related psychological constructs will be tested at pre- and post-intervention. The other behavioral theories and constructs will not be explored.

3) This study will be carried out in school settings only and the videos will not be installed at home during the intervention.

4) The intervention will be implemented within the children in the Grade four to six from primary school with English Medium Instruction and the students from other grades or secondary and other schools will not be recruited.

Limitations

1) Since the video game is applied for children with good English abilities, the effects of the video game-based intervention can't be explained in all the age-matched children.

2) The findings of the study are not able to generalize to other population. Additional research can be expected to conduct among a large scale age scope and population.

Definition of terms

Childhood overweight and obesity: Overweight and obesity is defined as a condition where an excess of body fat is present in an individual. BMI, weight-to-height index, skinfold thickness, circumference measure, body fat percentage, or others are applied as the references to define overweight and obesity. However, there is no consensus definition of childhood obesity. Cut points for various ethnic origins to classify children into overweight and obesity are different. In this thesis, overweight and obesity were defined using the recently developed international age- and sex- specific cut off points (Cole, Bellizzi, Flegal, & Dietz, 2000).

Physical activity (PA): PA is defined as any bodily movement produced by skeletal muscles that results in energy expenditure beyond resting expenditure (Caspersen, Powell, & Christenson, 1985).

Moderate-to-vigorous physical activity (MVPA): MVPA refers to the moderate- and vigorous- intensity activities. Moderate-intensity PA requires a moderate amount of effort and noticeably accelerates the heart rate (e.g., brisk walking, dancing, gardening, et al.).

Vigorous-intensity PA requires a large amount of effort and causes rapid breathing and a substantial increase in heart rate (e.g., running, fast cycling, aerobics, et al.) (WHO, 2014). The cut off points developed by Evenson and colleagues (2008) were applied to define MVPA (≥ 2296 counts per minute) in this thesis.

Serious games: Serious games is defined as digital games, simulations, virtual environments and mixed reality/media that provide opportunities to engage in activities through responsive narrative/story, gameplay or encounters to inform, influence, for well-being, and/or experience to convey meaning (Marsh, 2011, p.63).

Games for health (G4H): G4H is one particular type of serious game which are designed to encourage players to modify attitudes and behaviors to health through playing and entertainment (Thompson et al., 2008).

Story immersion: Story immersion is a phenomenological experience of people's engagement with narratives, a process in which people travel into the story world and are changed by the journey (Gerrig, 1993).

Chapter 2 Literature Review: The Effects of Video Games-based Intervention on Children's Obesity-related Behaviors

Abstract

Background: Video game playing is now a phenomenon woven into fabric of children's life. Even the controversy on the negative issues of video game usage exist, some benefits can be obtained for specific purpose. The objective of this study was to evaluate the effects of video games-based intervention on children's obesity-related behaviors.

Methods: Literature was identified through electronic database (EMBASE, MEDLINE, Ovid PsycINFO, BIOSIS previews and the Cochrane Central Register of Controlled Trials). Studies were eligible if they described the experimental or quasi-experimental trial examining the effect of intervention by using video games on children's PA- and dietary-related outcomes published in English from 2005 to March 2015.

Results: Of 2635 potentially articles retrieved, 29 passed the eligibility criteria and 27 were included in the analysis with acceptable scores of methodological quality. Among 20 studies measured PA or MVPA, 6 (30%) studies showed the positive evidence in PA engagement. Eight out of 14 (57.1%) studies examined the anthropometrical measures (e.g., BMI, body weight, waist circumference, or skinfold, or body composition) indicated the promising improvement on the effectiveness of intervention. All the 6 studies discussed the psychological constructs provided positive findings. However, the tests of dietary aspects were performed in 3 cases and 2casses (66.7%) demonstrated the promising evidence. Only five of 27 included studies conducted the follow up test on the lasting effects of the treatments.

Conclusion: Published studies employing video game enable psychological correlates of PA and dietary outcomes. Limited evidence is available to draw conclusion on their consequent efficacy on behavior modification. Further researches with long-term effects of video games are needed.

Introduction

A "Video game" was defined as an electronic or computerized game played by manipulating images on a video display or television screen (Primack et al., 2012). Today's video game players defy traditional stereotypes. Video game playing is now a phenomenon woven into the fabric of life and has been developed to educate individuals in health-related areas as varied as supporting psychotherapeutic treatment (Wilkinson, Ang, & Goh, 2008), improving self-esteem (Baccus, Baldwin, & Packer, 2004), conflict resolution (Allan, 2005), and knowledge and self-management of diseases (Kumar, Wentzell, Mikkelsen, Pentland, & Laffel, 2004). Video gaming is considered an emerging technology with the potential to overcome many of the current barriers to diet and PA in children. Two recent literature reviews were conducted to assess the potential value of video games in the effect of promoting health. In one (Baranowski et al., 2008), authors searched Medline and their personal files for relevant studies. The emphasis was on the use of video games' characters with story genre, interactivity, and fantasy. The included articles were not limited by design. In another review, authors assessed the usefulness of video games for improving health-related outcomes as evidenced by studies with rigorous designs. However, the targeted participants were too widely distributed, from child to older adult, and the health topics included postural instability, PA, stroke, and cancers; additionally, some of the reviewed studies in the analysis were observational in nature (Primack et al., 2012). The review of Liang et al. (2014) contained the survey studies and intervention studies by using AVGs. The effects of other types of health videogames were not examined.

The aim of the present review was to provide a more comprehensive, age-specific, and quantitative synthesis of the current state of video game intervention studies targeted obesity-related behaviors in children and adolescents. The objectives were to examine the role of video games on children's PA and diet and identify the intervention characteristic with which to inform the design of the subsequent intervention study in this thesis. Specifically, two research questions will be included in this review: (1) What were the characteristics of health videogame studies on the obesity prevention among children and adolescents? (2) What were the effects of these interventions?

Methods

Search strategy

A literature review of the literatures via EMBASE, MEDLINE, Ovid PsycINFO, Sport Discus, BIOSIS previews and the Cochrane Central Register of Controlled Trials was conducted to using combinations of the following keywords and their relevant suffixes: (video game OR exergame OR interactive game OR electronic game OR serious game as well as combinations of these items) AND (child* OR adolescent * OR teenag* OR youth), for publication in English, between 2005 and March 2015. After screening the abstracts, manual cross-referencing of bibliographies was also completed. Multimedia education game without participants' operation was excluded and out of review.

Eligibility criteria

The selection criteria were: 1) Articles had to have been published in international academic peer-reviewed journals (book chapters, abstracts of conference proceeding and dissertations were excluded); 2) Participants included were at least one subgroup of

children and adolescent (age < 18); 3) The studies were not restricted to RCT study design. Studies that implemented the experimental and quasi-experimental intervention were both included. 4) Studies had to meet the criterion of testing obesity-related outcomes. The assessed variables included physical fitness, psychological therapy, health education, disease self-management, PA and diet knowledge/skills et al. The selection criteria and subsequent searches were designed to be broad so as not to omit any relevant articles.

Data extraction

Table 2.1. Criteria of methodological quality

Item	Description
1	Were the eligibility criteria specified?
2	Was the method of randomization described?
3	Was the random allocation concealed? (i.e., Was the assignment generated by an independent person or responsible for determining the eligibility of the patients?)
4	Were the groups similar at baseline regarding important prognostic indicators?
5	Were both the index and the control interventions described?
6	Was the compliance or adherence with the intervention described?
7	Was the outcome assessor blinded to the interventions?
8	Was the dropout rate described and were the characteristics of the dropout compared with the completers of the study?
9	Was a long-term follow-up measurement performed (outcomes measured ≥ 6 months after randomization)?
10	Was the timing of the outcome measurements in both groups comparable?
11	Was the sample size for each group described by means of a power calculation?
12	Did the analysis include an intention-to-treat analysis?
13	Were point estimates and measures of variability presented for the primary outcome measures?

Reprinted from 'Internet-based physical activcity intervention: a systematic review of literature', by van den Berg, M. H., Schoones, J. W., & Vliet Vlieland, T. P., 2007, *J Med Internet Res, 30(9), e26*. Copyright 2007 by JMIR Publications Inc.

Extracted data included: 1) study background information such as study location and source of funding (year of publication, country in which study was conducted); 2) study information (study design, sample size, participant demographics); 3) intervention and control-related information, such as the type of video games used in the intervention and control and the duration and intensity of the intervention; 4) outcomes-related information such as the primary and secondary outcomes of interest. The quality of trials evaluating health videogame interventions was further assessed using a 13-item scale developed in a previous review (van den Berg, Schoones, & Vliet Vlieland, 2007) (Table 2.1). Each item was rated as 'Yes", 'No", or 'Unknown". A total methodological quality score (ranging from 0-13) was calculated by summing up all 'YES" items. Since the study aimed to review the literatures on the video game-based interventions and provide a whole picture of this type of research, we tried to include all the related studies in the review and did not miss any useful information. Thus, an acceptable methodological quality (≥ 4 items) was set in the current review. The studies if they met this criterion were finally included. In future study, the analysis between high and low quality of studies could be further conducted. Data extracted from intervention studies were summarized, tabulated, and compared.

Results

Selection of articles

Figure 2.1 provides a flowchart documenting the results of literature selection process. A total of 2635 articles were identified initially. During the reviewing process, the author found there were 13 studies carried out within special populations, e.g. the

children with Cerebral Palsy, Down Syndrome, or Cancers, additionally, 6 reviews and 3 proposals on the video games were found. All these studies were excluded in the final analysis because of their unsatisfactory with the selection criteria. After removing duplicates and irrelevant studies, 29 articles were found examining the effect of the different types of video games on children's behavior. Of the 29 papers, two papers (Maddison et al., 2011; Maddison et al., 2012) represented the same trial which had been conducted in New Zealand with different perspectives of analysis. Maddison et al., (2011) was kept in the analysis. Except one trial (Fogel, Miltenberger, Graves, & Koehler, 2010), all the studies got the methodological score higher than 4 and were

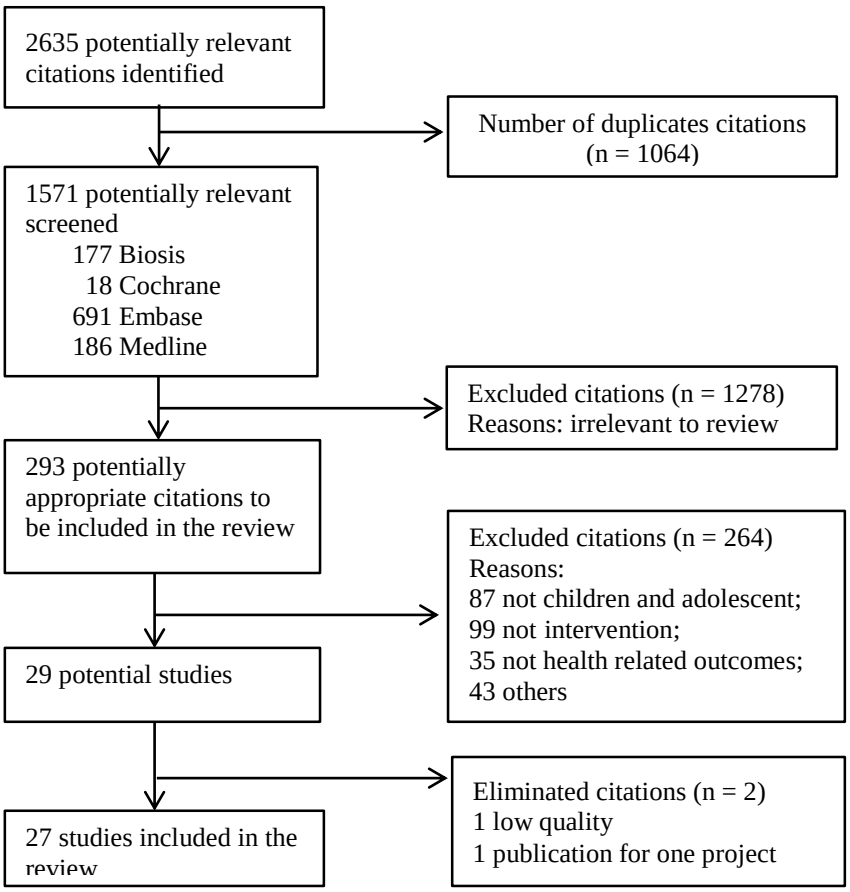

Figure 2.1. Results of the Literature Search

included into the review. The study of Fogel and colleagues (2010) designed to explore the effects of exergaming on PA among inactive children in a physical education classroom was scored as low quality due to its small sample size (n = 4 children), and was not included in the final analysis.

Study characteristics

Methodological details from the remaining 27 articles are summarized in table 2.2.

Year of publication

The number of studies increased across the years. Five studies (18.5%) were published before 2008 and 8 studies (29.6%) were published during 2009 to 2011. Half of the studies (n = 14, 51.9%) were published since 2012.

Location

All studies were conducted in Western countries. The United States was the main country for the published studies (n = 20, 74.1%), compared with two studies (7.4%) in New Zealand, three studies (11.1%) in United Kingdom, one (3.7%) in Netherland and Italy, respectively.

Design

Of the 27 included studies, 12 (44.4%) adopted RCT design. Nine studies (33.3%) included controlled group with non-randomized allocation. Six studies (22.2%) had a treatment group only. The study of Staiano et al. (2013) was three arms design with the cooperative, competitive exergame and control groups. The study of Thompson et al. (2015) consisted of four paralleled groups.

School setting

Half of the studies (n = 14, 51.9%) were performed at home. School was the second most popular venue (n = 10, 37.0%). One study was conducted both in school and home and one study was community-based.

Table 2.2. Summary of the characteristic of included studies

Characteristic	Reference ID	Count	%
Year of publication		27	100
2005-2008	1,2,13-15	5	18.5
2009-2011	3-7,16-18	8	29.6
2012-2015	8-12, 19-27	14	51.9
Location			
United States	3,4,6, 8-16,18-21,23-25,27	20	74.1
New Zealand	1,7	2	7.4
United Kingdom	5,17,26	3	11.1
Netherland	2	1	3.7
Italy	22	1	3.7
Design			
RCT	1-12	12	44.4
Non-RCT controlled	13,15-18,21,24,26 27	9	33.3
Treatment only	14,19,20, 22,23,25	6	22.2
Study setting			
School	13,16,17,19,21,23-27	10	37.0
Home	1,3-12,14,15,18	14	51.9
School + home	2	1	3.7
Community	20	1	3.7
Research institute	22	1	3.7
Sample size			
≤50	1-3,5,14,17-20,22	10	37.0
51-100	8,9,11,15,21,24	6	22.2
101-200	6,10,16,27	4	14.8
≥201	4,7,12,13,23,25,26,	7	25.9
Gender			
Both gender	1-3,5-27	26	96.3
Male only	4	1	3.7
Body weight status			
No distinction	1,2,4-6,8,9,12,15-19,21,23,25-27	18	66.7
Normal + overweight	10,13	2	7.4
Overweight + obese	3,7,11,20,24	5	18.5
Obese	14,22	2	7.4
Project duration			
≤9 weeks	4, 6,10,13,17,21	6	22.2
10-20 weeks	1-3,5,8,9,11,12,16,18,20,22,24,25	14	51.8
21-40 weeks	7,14,15,19	4	14.8
≥41 weeks	23,26,27	3	11.1

Table 2.2. (*Continued)*

Characteristic	Reference ID	Count	%
Follow up test			
Yes	4,6,10,12,14	5	18.5
No	1-3,5,7-9,11,13,15-17,18-27	22	81.5
Theory integration			
Yes	4,6,8,10,12,13,16,25,26	9	33.3
No	1-3,5,7,9,11,14,15,17-24,27	18	66.7
Health behaviors			
Nutrition	12	1	3.7
PA	1-3,5,7-9,11,13-27	23	85.2
Nutrition + PA	4,6,10	3	11.1
Change in obesity-related outcome			
Significant	11,19,20	3	11.1
Partially significant	1-10,12,13,15-18,22-27	22	81.5
No significant	14,21	2	7.4

Sample size

The 27 included studies contained a total of 3676 participants and the sample size ranged from 12 to 473 in each study. Tens studies (37.0%) had less than 50 participants and seven studies (25.9%) had the sample size larger than 200.

Gender

Expect one study (Thompson et al., 2009) recruited male only, all the studies recruited both genders.

Body weight status

Eighteen studies (66.7%) did not set the criteria for participants' body weight status. While, 2 studies (7.4%) recruited obese children and 5 studies (18.5%) contained overweight and obese children by using BMI percentiles as recruitment screening. The remaining two studies (18.5%) had normal and overweight participants. The participants in one study (Paw, Jacobs, Vaessen, Titze, & van Mechelen, 2008) were classified based

on the 20-meter shuttle run test and those with scores below the median for this age and gender group were recruited in the study.

Intervention efficacy

This review included both RCT and non-RCT. The effects of video game-based intervention on behavior outcomes are detailed in Table 2.3. for RCT and non-RCT, respectively. Regarding change in obesity-related outcomes, the intervention effects were classified into three types: significant (all the reported outcomes improved after intervention); partially significant (at least one but not all of the measured outcomes showed improvement from the treatment); no significant (no detected intervention effect on all the outcomes). We compared the intervention effects of RCT and non-RCT on the outcomes, no significant differences were found among studies with different design. Thus, overall information on the intervention efficacy was extracted from all the included studies including both RCT and non-RCT.

Video game

In terms of the video games used in the interventions, Dance Dance Revolution (DDR) (n = 12, 44.4%) and AVGs (n = 10, 37.0%) were the most two popular video games. The others were Dance Simulation Video Game (IDSVG), jOG, Eacape from Diab, Nanoswarm, Interactive Multimedia for Promoting Physical Activity (IMPACT), Color My Pyramid, Squire's Quest. Among of these health videogame, 3 (11.1%) contained the story in the game, where the rest did not.

Project duration

The intervention duration ranged from nine sessions (n = 2) to one years (n = 1). The majority of intervention lasted within 20 weeks (≤9 weeks, n = 7, 25.9%; 10-20 weeks, n

= 13, 48.1%). Four studies (14.8%) were conducted at a moderate duration with 21 to 40 weeks. Only three studies (11.1%) took place in a long duration with more than 40 weeks.

Follow up test

Only 5 (18.5%) out of 27 studies conducted the follow up test to examine the lasting effects of intervention. The intervals between post test and follow up test were mostly similar with the interneuron duration.

Theory integration

Regarding theoretical foundations, one third (n = 9, 33.3%) of the studies explicitly stated the theoretical basis of their intervention. SCT was the most integrated theory (n = 6). One study applied SDT, Self-efficacy, and Self-care Deficit Nursing Theory, respectively. Three studies adopted the combination of multiple theories, e.g., Behavioral inoculation theory, Elaboration likelihood model, and SDT.

Health behaviors

Two types of obesity-related behaviors were identified in the studies: Nutrition and PA. Most studies (n = 23, 85.2%) focused only PA aspect. One study (3.7%) examined the intervention effect on nutrition only. There were three studies (11.1%) worked on both sides of energy balance.

Obesity-related outcome

The majority of the included studies evaluated both behaviors (diet or PA) and anthropometric indicators (BMI, WC, blood pressure, skinfold etc.). The studied with integration of theory measured the psychological correlates as well, for example, motivation, self-efficacy, enjoyment etc.

Table 2.3. Key findings of the included studies (n = 27)

No,	Sources	Participants	Study information	Intervention information	Main findings
RCT studies (n = 12)					
1	Ni Mhurchu et al. (2008), New Zealand	20 children (12.0 ± 1.5yrs), F/M	Design: RCT Setting: Home Video Game: Upgrade package consisting of an EyeToy camera, EyeToy active games, and dance mat Outcomes: PA, WC and BMI	Duration: 60 minutes/day × 12weeks Theory: N/A Int: substitute usual non active video game play with AVG Cont: no intervention	Significant: more time playing AVG (diff: 14 min/day), less time spent playing inactive games (diff: -52min/day), WC difference (diff: -1.4cm) No significant: time spent in MVPA measured by accelerometer, body weight difference
2	Paw et al. (2008), Netherland	27 children aged 9-12 yrs (10.6 ± 0.8yrs), F/M	Design: RCT Setting: Home + school Video game: Interactive dance simulation video game (IDSVG) Outcomes: Aerobic fitness, BMI, PA and sedentary behavior assessed, motivation	Duration: Daily session over 12 weeks Theory: N/A Int: IDSVG for home + once weekly in 60 min multiplayer class Cont: IDSVG for home use	Significant: dropout was lower (15%) than in the home group (64%) No significant: the trend that more play time in the multiplayer group than the home group (diff: 525 min)
3	Murphy et al. (2009), USA	35 overweight children (10.21 ± 1.67yrs), F/M	Design: RCT Setting: Home Video game: DDR Outcomes: Metabolic indicators	Duration: 10-30 minutes/session × 5/weeks × 12weeks Theory: N/A Int: aerobic exercise using DDR Cont: delayed-treatment control group	Significant: flow-mediated dilation, aerobic fitness, mean arterial pressure in overweight children had been improved No significant: no improvements occurred without changes in the inflammatory markers and nitric oxide production
4	Thompson et al. (2009), USA	473 participants aged 10- 14 yrs, M only	Design: RCT Setting: Home Video game: Solve it; What Moves You Outcomes: diet and MVPA	Duration: 55 min /week × 9 weeks Follow up: 6 months Theory: SCT Int: 30minute of weekly troop time plus 25 min of weekly	Treatment group saw behavioral change in fruit and juice consumption and home availability, and low fat vegetable consumption, but the improvement was not maintained 6 months later

				internet program each week Cont: Active-attention-placebo-control	
5	Graves et al. (2010), UK	42 children aged 8-10yrs, F/M	Design: RCT Setting: Home Video game: device (jOG) Outcomes: PA, game time, body fat	Duration: 12 weeks Theory: N/A Int: received two jOG devices Cont: no intervention	Significant: AVG time increased, sedentary video gaming decreased No significant: counts per minute, body fat
6	Baranowski et al. (2011), USA	133 children aged 10-12 yrs , F/M	Design: RCT Setting: Home Video game: Escape from Diab (Diab) and Nanoswarm: Invasion from Inner Space (Nano) Outcomes: serving of fruit, vegetable and water, MVPA	Duration: 40 minute/session × 9 sessions × 2 games Follow up: 2 months Theory: SCT/ SDT/BIT/ELM Int: played Diab and Nano in sequence Cont: knowledge-based games on popular websites	Significant: increased fruit and vegetable consumption by about 0.67 serving No significant: water, MVPA and body composition didn't change.
7	Maddison et al. (2011), New Zealand	322 overweight and obese children aged 10-14 yrs, F/M	Design: RCT Setting: Home Video game: upgrade (hardare and games) enabling to play Sony PlayStation EyeToy AVG Outcomes: BMI, body fat, PA, cardiorespiratory fitness, video game play, and food snacking	Duration: 60 minutes/day × 7/week × 24weeks Theory: N/A Int: play the offered AVG, and to ensure the sustainability the new AVG was sent at 12 weeks. Cont: no intervention during the study	Significant: the treatment effect on BMI favored the intervention group, reduction in body fat and time spent playing nonactive video games, increased in time spent playing AVG No significant: cardiorespiratory fitness, food snacking
8	Baranowski et al. (2012), USA	78 children aged 9-12 yrs (11.3 ± 1.8yrs), F/M	Design: RCT Setting: Home Video game: Wii Fit, EA Sports Active, DDR Outcomes: PA	Duration: 13 weeks Theory: SDT, SCT, BIT, ELM Int: received 2 active video games Cont: 2 inactive video games	Significant: more active in general, or at any time No significant: the outcome were not moderated by parents perceived neighborhood safety, child BMI z score or other demographic characteristics

9	Errickson et al. (2012), USA	60 children aged 7 and 8 yrs (40 in the IG group), F/M	Design: RCT Setting: Home Video game: DDR Outcomes: PA	Duration: 120 minutes/week × 10 weeks Theory: N/A Int: A DDR prescription with more learning principles Cont: Basic DDR	Coaching significantly increased DDR use patterns in children during week 1 through 5.
10	Lu et at al. (2012), USA	153 children aged 10-12yrs (11.3 ± 1.8yrs), F/M	Design: RCT Setting: Home Video game: Escape from Diab Outcomes: Immersion, and health outcomes (preference, motivation and self-efficacy)	Duration: 9 sessions, 40 min/session Theory: SCT/ SDT/BIT/ELM Follow up: 2 months Theory: N/A Int: played 'Escape from Diab' Control: The playing health-related videogames.	Significant: Story immersion correlated positively with an increase in Fruit and Vegetable Preference. Intrinsic Motivation for Water, Vegetable Self-efficacy, and PA Self-Efficacy.
11	Trost et al. (2014), USA	75 overweight and obese children with mean age at 10.0 (1.7) yrs, F/M	Design: Group-randomized trial Setting: Home Video game: AVG Outcomes: MVPA, percentage overweight, BMI z score	Duration: 16 weeks Theory: N/A Int: Two AVG programs, on received at the begin, the other one at 9 week plus comprehensive pediatric weight management program Cont: Program only	The intervention group exhibited significant increases in MVPA (7.4 (2.7) minutes/day) and significant greater reductions in percentage overweight (−10.9%[1.6%] vs −5.5%[1.5%]) and BMI z score ((−0.25 [0.03] vs −0.11 [0.03]).
12	Thompson et al. (2015), USA	400 children aged 9-11 yrs (100 in each group), F/M	Design: RCT Setting: Home Video game: Squire's Quest Outcomes: Fruit and vegetable intake	Duration: 10 sessions Follow up: 3 months Theory: SCT/SDT/BIT/MT/ELM Int: Children played game (set a goal and created a plan) plus parents received 10 electronic newsletters and access to a parent-only website Cont: Coping group, both action and coping group, control group	Significant fruit and vegetable intake increase was found in the action group.

Non-RCT studies (n = 15)					
13	Goran & Reynolds (2005), USA	209 children aged 8.8 to 11.1 yrs (9.5 ± 0.4 yrs), F/M	Design: Non-RCT controlled experiment Setting: School Video game: Interactive Multimedia for Promoting Physical Activity (IMPACT) Outcomes: PA	Duration: 45 minutes × 16 session over 8 weeks Theory: SCT Int: IMPACT supplemented by four classroom and four homework assignments Cont: Educational CD-ROMs not related to health outcomes	Significant treatment effect for obesity reduction among girls in BMI z-score and percentage of body fat.
14	Madsen et al. (2007), USA	30 obese children aged 9-18 yrs (13.0 ± 2.6yrs), F/M	Design: Experimental study without control group Setting: home Video game: DDR Outcomes: BMI	Duration: 30 minutes / day × 5 days/week × 24 weeks Follow-up: 6 months Theory:N/A Int: used DDR 30 min/d, 5d/week and recorded Cont: N/A	No significant: use of DDR was not associated with change in BMI from baseline at either 3 or 6 months.
15	Maloney et al. (2008), USA	60 children (7.5 ± 0.5yrs), F/M	Design: Non-RCT controlled experiment Setting: Home Video game: DDR Outcomes: PA, sedentary screen time	Duration: 30 minutes/day × 4 days/week × 28 weeks Theory: N/A Int: DDR play + log Cont: no intervention	Significant: Vigorous PA increased and light PA decreased in treatment group No significant: the control group change
16	Moore et al. (2009), USA	126 children aged 9 -11 yrs, F/M	Design: Non-RCT controlled experiment Theory: SDNT Setting: School Video game: Color My Pyramid Outcomes: Knowledge, self-care practices. PA and nutrition	Duration: 6 times over 3 months Int: Corlor My Pyramid with incorporation an online component Cont: N/A	Scores for self-care practices, activity, and systolic blood pressure improved significantly but not BMI percentiles.

17	Duncan & Staples (2010), UK	30 children aged 10-11 yrs (10.4 ± 0.5yrs), F/M	Design: Non-RCT controlled experiment Setting: School Video game: Wii Sports, Sonic and Mario at the Olympics Outcomes: PA	Duration: 6 weeks Theory: N/A Int: twice weekly sessions of AVG during school lunch breaks Cont: N/A	Significant: The intervention's children accumulated significantly greater steps/day than control group during 1st week. The pattern was reversed at the mid and end points. Children engaging in AVG spent a lesser percentage of MAPA time than controls undertaking children's PA.
18	Owens et al. (2011), USA	12 children aged 8-13yrs (10.0± 1.6yrs), F/M and their parents were involved	Design: Non-RCT controlled experiment Setting: Home Video game: Wii Fit™ Outcomes: PA, muscular fitness, flexibility, balance or body composition	Duration: 3 months Theory: N/A Int: use Wii Fit at home at the discretion of participants Cont: use the game after a 3 month waiting period	Significant: an age group × time interaction was observed in peak VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$) with children displaying a significant increase after 3 month of use. Daily Wii Fit™ use per household declined during the first two 6 weeks.
19	Bethea et al. (2012), USA	28 treatment participants aged 8 -11 yrs (9.9 ± 0.7 yrs), F/M	Design: Experimental study without control group Setting: School Video game: DDR extreme Outcomes: MVPA, physical fitness	Duration: 30 minutes × 3/week × 30 weeks Theory: N/A Int: afterschool program Con: N/A	VO_{2max} increased by 4.9 ± 9.9% and was sustained through 30 weeks. Absolute $VO_{2max\ increased}$ by 2.97 ± 4.99 mL/kg/minute. An average of 1.12 hours/day of increased movement to music was maintained.
20	Christison & Khan (2012), USA	48 treatment overweight and obese children aged 8 -16 yrs (11.2 ± 2.2 yrs), F/M	Design: Experimental study without control group Setting: Community Video game: AVGs Outcomes: Weight intervention, PA	Duration: 120 minute week × 10 week Theory: N/A Int: Playing the AVGs Cont: N/A	Average BMI change was -0.48 kg/m2. Average Global Self-Worth score improved, screen time and soda, intake were reduced, and exercise hours per week increased.

21	Sun (2012), USA	74 children aged 9-12 yrs, F/M	Design: Non-RCT controlled experiment Setting: School Video game: Eight exergaming stations, including Boxing, Wiis, DDR, etc. Outcomes: PA, attention, enjoyment, challenge, exploration	Duration: 30 minutes/week × 4 weeks Theory: N/A Int: Integration with physical education class Cont: Common activates, e.g., jump rope, running and jogging	Using exergaming as viable content in physical education demonstrated the power of may reside in the lasting effects of challenge, exploration, and instant enjoyment.
22	Calcaterra et al. (2013) , Italy	22 treatment participants aged 9 -16 yrs with BMI ≥ 95th percentiles, F/M	Design: Experimental study without control group Setting: Research institution Video game: Dance, Wii fit, Wii fit plus Outcomes: Weight management	Duration: 90 minutes × 2/week × 12 week Theory: N/A Int: Game play 5-10 minutes per 90-minutes session Cont: N/A	Significant decreases in BMI, SDS-BMI, WC, WC/height ratio, fat mass, blood glucose, HOMA-IR, SBP before and after exercise
23	Gao et al. (2013), USA	268 students in Grades 3rd to 5th aged 10-12 (Mean ± SD age= 10.32± 0.91yrs), F/M	Design: Crossover design Setting: school Video game: DDR Outcomes: 1-mile run, BMI	Duration: 30 minutes × 3 weeks × 52 weeks Theory: N/A Int: 30min PA program based on DDR three times per week Control: no intervention	Significant: net difference in the intervention versus comparison group scores on the 1-mile run. BMI group changes differed only for the first year. No significant: the changes of BMI in 2nd year.
24	Staiano et al. (2013), USA	54 overweight and obese adolescents (55.6% aged 15-19yrs), F/M	Design: Non-RCT controlled experiment Setting: School Video game: Nintendo Wii Outcomes: weight, self-efficacy and self-esteem	Duration: 20 week Theory: N/A Int: encouraged to play active game for 30-60 min per school day in a lunch-time or after school program (cooperative vs. competitive exergame) Control: regular daily activities	Significant: cooperative exergame players lost significantly more weight (mean = 1.65kg) than control group, which did not lose weight, and also significantly increased in self-efficacy compared to the control group. The competitive exergame players did not differ significantly from the other conditions.

25	Gao et al. (2013), USA	215 treatment participants aged 8-14yrs (Mean ± SD age= 11.2± 1.11yrs), F/M	Design: Experimental study with no control group Setting: School Video game: DDR Outcomes: motivation, MVPA and PA enjoyment	Duration: 18 weeks Theory: SDT Int: attended a weekly 30-min physical education class	Significant: PA enjoyment was significantly predicted by intrinsic motivation, and the later one positively predicted children's MVPA in the model. Children reported relatively high PA enjoyment. No significant: Children were not very active when playing DDR.
26	Azevedo et al. (2014), UK	497 children aged 11-13 yrs (280 in the treatment group), F/M	Design: Non-RCT controlled experiment Setting: School Video game: Dance mat Outcomes: PA, rating of perceived exertion, body composition, self-efficacy	Duration: 1 year Theory: Self-efficacy Int: Five intervention strategies, first 6 weeks with structured delivery, the remaining with natural use Cont: Blank control	Significant positive intervention effect on weight (-1.7 kg, 95%CI: -2.9 to -0.4), BMI (−0.9 kg/m^2, 95% CI: −1.3 to −0.4) and percentage of body fat (−2.2%, 95% CI: −4.2 to −0.2). Improvement in psychological well-being (2.5, 95% CI: 0.1 to 4.8) and autonomy and parent relation (4.2, 95% CI: 1.4 to 7.0).
27	Gao & Xiang (2014), USA	185 children with mean age at 10.3 yrs, F/M	Design: Non-RCT controlled experiment Setting: School Video game: DDR and 1 center activity station Outcomes: PA, body composition	Duration: 30 minute/session × 3 times/week × 9 months Theory: N/A Int: 15 minute DDR plus 15 minutes center activity Cont: Blank control with conventional unstructured recess	Intervention children had significantly greater increased PA levels than comparison children but not in body composition.

Note: F/M, The study included both female and male; N/A, Not applicable; RCT, Randomized controlled trial.
SCT, Social cognitive theory; SDT, Self-determination theory; BIT, Behavioral inoculation theory; MT, Maintenance theory; ELM, Elaboration likelihood model, SDNT, Self-care deficit nursing theory
Int, The intervention group; Cont, The control group.
BMI, Body mass index; WC, Waist circumference; PA, Physical activity; MVPA, Moderate-to-vigorous PA; VO_2, O_2 uptake volume; $VO_{2\,max}$, Maximum O_2 uptake volume.
AVG, Active video game; DDR, Dance Dance Revolution;

Regarding the outcome variables, PA was the overriding variable. Of the 27 studies, 20 studies measured PA or MVPA objectively or subjectively as one of the outcomes. There were 14 studies focused on the BMI, body weight, waist circumference (WC), skinfold, or body composition. Several studies focused on psychological variables (n = 6), metabolic indexes (n = 1), physical fitness (n = 4) and serving of fruit, vegetable and water (n = 3).

Change in obesity-related outcome

The majority of studies (n = 22, 81.5%) showed partially significant effect on obesity-related outcomes. Two intervention studies (7.4%) did not improve the related health outcomes. Three studies (11.1%) revealed the positive improvements on outcomes.

Six of the 20 studies which had measured PA or MVPA showed evidence on the effective interventions in improving PA. Graves et al. (2010) found the AVG time increased and sedentary video game time decreased. Mhurchu et al. (2008) also found that intervention increased AVG playing time, and decreased time spent playing inactive games, but there was no significance in the time spent in MVPA. Maddison et al. (2011) found the children in the intervention group decreased their time spent playing non-active video games, and increased the time spent playing AVG. Duncan et al. (2010) discovered that the intervention group accumulated a significantly greater amount of steps per day than the control group during the first intervention week, but this effect did not persist at follow up. Two studies showed the PA levels increased after intervention (Azevedo et al., 2014; Gao, Podlog, et al., 2013). An increase of MVPA (mean (SD): 7.4 (2.7) minutes/day) was observed in the study of Azevedo et al. (2014). However, Baranowski and colleagues (2012) did not find the evidence that

children from intervention group receiving AVGs were more active than children receiving the inactive video games.

Among the studies reviewed, 14 studies had examined the anthropometrical indicators (e.g., BMI, body weight, WC, or skinfold, or body composition). Eight studies indicated promising evidence at least one of anthropometrical variables. Maddison et al. (2011) found that the treatment effect on BMI favored the intervention group with a reduction in body fat. Mhurchu et al. (2008) found a significant WC difference between groups after intervention. In the study of Staiano et al. (2013), the cooperative exergame players lost significant amount of weight (mean = 1.65 kg) compared to the control group. Azevedo's (2014) study showed the positive effects on body weight management on weight (-1.7 kg, 95%CI: -2.9 to -0.4), BMI (−0.9 kg/m^2, 95% CI: −1.3 to −0.4) and percentage of body fat (−2.2%, 95% CI: −4.2 to −0.2). Although Gao et al. (2013) found that the BMI of intervention group changed, the changes differed only for the first year without effect in the second year.

Generally, psychological indexes are regarded as mediators or moderators for the behavior modification programs. In this review, 6 of the 27 studies discussed the related psychological correlates and all these studies showed the positive intervention effects. Brown et al. (1997) explored the effect on young people's diabetes related self-concepts, social support, knowledge and self-care. It was found the video game increased in the diabetes-related self-efficacy, communication about diabetes and self-care behaviors and decreased unscheduled urgent doctor visits. In the study of Staiano et al. (2013), the cooperative exergame intervention group also significantly increased their self-efficacy compared to the control group. Gao et al. (2013) found that PA enjoyment was significantly predicted by intrinsic motivation using DDR. Sun's study

(2012) demonstrated the exergame resided in the lasting effects of challenge, exploration, and instant enjoyment.

The intervention using video game also showed the improvements on overweight children's metabolic indicators. In the study of Murphy et al. (2009), mean arterial pressure in overweight children were improved. The studies showed the positive intervention effect on physical fitness on VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$) (Bethea et al., 2012; Owens et al., 2011) , and 1-mile run (Gao, Hannan, et al., 2013). However, Maddison and colleagues (2011) did not demonstrate the AVG intervention on participates' cardiorespiratory fitness.

In the current review, only 3 studies investigated the intervention on severing of dietary behaviors. Baranowski and colleagues (2011) found the video game intervention increased fruit and vegetable consumption by about 0.67 servings. Thompson et al. (2015) also found the significant fruit and vegetable intake increase in the action group. However, in the study of Maddison et al. (2011), the change in food snack consumption was not found.

Discussion

This section reviewed the efficacy of video game-based interventions on obesity-related outcomes in children and adolescents with no restriction of study design from 2005 to March 2015. Even the increasing numbers of intervention articles is published, a small number of included intervention studies (n = 27) indicates the demands for more research with this technology to combat the severe childhood obesity epidemic.

All the reviewed articles were from Western countries, which call for the projects among Asian youth. Even no differences on the intervention effects were found

between RCT and non-RCT, less than half of the studies adopted RCT design that may limit the internal and external validity of the studies. More than half of the included studies (n = 16, 59.2%) had a small sample size (≤ 100), which may influence the power to detect the significant statistical results. The intervention durations were relatively short. In future, the high quality research is required to overcome these limitations and fully evaluate the video game-based intervention.

Videogames are generally considered as being primarily created for home entertainment (Phillips, Rolls, Rouse, & Griffiths, 1995). In the review, half of the studies were conducted at home. Recently, health videogames for childhood obesity prevention have been applied beyond the home setting. Children spend most of their awake time at school with classmates or teachers. The recreational facilities in schools also provide the potential venues to use the video games. In this review, ten included school-based interventions showed partial improvements on health-related outcomes. Compared to home setting, it is easy to detect and monitor the intervention process, which can help to evaluate the intervention delivery and exposure. Computer and game consoles may get involved in school and community settings to be additions to their recreational facilities.

AVGs are the dominating devices among the video games using in the intervention. Active video games can enable children to participate in moderate physical activity under laboratory conditions (Graf, Pratt, Hester, & Short, 2009). Although evidence shows that some AVGs were able to increase children's energy expenditure of children even to the recommended level to achieve the corresponding health fitness (Graf et al., 2009), the present review did not find sufficient evidence to support this view. Some AVG intervention studies have found it is difficult for children to play one type of AVG over a long period of time (Biddiss & Irwin, 2010;

Madsen et al., 2007). Twelve out of 21 children used DDR at least twice a week in the initial 3-month period. Subjects completing a diary, tended to have the highest use, however, use declined over time. This may be one of the reasons why some free-living AVG interventions have not been effective. Twelve of the 27 included intervention studies used dance partially or mainly, which also limit the summary for the review because the results in other technologies may differed.

A range of theories and models has been used to specify variables that are demonstrated to influence PA and other behaviors (Bauman, Sallis, Dzewaltowski, & Owen, 2002). The concepts of self-efficacy and motivation are receiving increasing recognition as predictors of health behavior change and maintenance (Strecher, DeVellis, Becker, & Rosenstock, 1986). In the present review, only one third of the studies (n = 9) explicitly stated the theoretical basis of their intervention, among these, six studies measured the psychological correlates as outcomes. All the six studies showed the positive intervention effect. Particular constructs (motivation, self-efficacy, enjoyment and so on) from theories are critical antecedents of behavioral engagement. These constructs are hypothesized as components of a causal chain, suggesting that if the mediators are changed under the action of intervention, behavior change may follow (Noar & Zimmerman, 2005). Psychological correlates from theories are suggested to integrate in the intervention to explore the mechanism of behavioral modification.

Considering the risk of obesity resulting from an imbalance between energy intake and expenditure, obesity should be intervened upon using a two pronged approach. However, there is insufficient information with which to examine the dietary aspect of video game-based interventions in the present review. Only 4 studies have investigated the effects of video game effect on diet-related outcomes. The

majority of studies have applied AVG (DDR or Wii Fit, et al) to target PA as the only outcome. Thus, more video games focused on both diet and PA are required to be designed and applied and fresh ideas are needed to push the field forward.

Among the video game used in the studies, most of them are commercial games. However, only three video games have the storyline. A positive finding was discovered the relationship between story immersion video game and health outcomes (Lu, Thompson, et al., 2012). Story immersion correlated positively with an increase in fruit and vegetable preference, intrinsic motivation for water, vegetable self-efficacy, and PA self-efficacy. Story provides a powerful motivation to continuously engage players (Lu, Baranowski, Thompson, & Buday, 2012). Future development of obesity prevention game could incorporate the narrative storyline into the design.

Duncan et al. (2010) discovered that the intervention group accumulated a significantly greater amount of steps per day than the control group during the first intervention week, but this effect did not persist at follow up. In the study of Thompson et al. (2009), treatment increased in fruit and juice consumption, and decreased in low fat vegetable consumption. However, these improvements were not maintained 6 months later. Among of 27 included studies, only 5 studies conducted the follow up test. A longitudinal design is encouraged for future studies to examine the lasting effect of the treatment.

Conclusion

Although a meta-analysis cannot be conducted due to the heterogeneity of the measures and designs, the findings from the review provide important and useful information to inform the intervention design. Published studies employing video game were able to promote psychological correlates of PA and dietary outcomes.

However, limited evidence is available from which to draw conclusion regarding their consequent efficacy on behavior modification. Further research with rigorous design and long-term follow up test to assess the effects of video games is encouraged.

PA is an important aspect of energy balance. However, there is limited validated questionnaire to measure PA in Chinese children. The following chapter documents the translation and validation of a self-reported PA questionnaire, which would be used in the subsequent cross-sectional and experimental studies.

Chapter 3 Study 1: Validation of the Physical Activity Questionnaire for Older Children (PAQ-C) among Chinese Children

Abstract

Background: The Physical Activity Questionnaire for Older Children (PAQ-C) has been identified as a potentially valid instrument to assess MVPA in children and adolescents and has been tested among diverse racial groups. Currently however, there are no data supporting the use of the PAQ-C in Chinese samples. This study initially validates the Chinese version of the PAQ-C.

Methods: This studies (n = 469) with Hong Kong Chinese children examined the characteristics of the questionnaire. The scale's internal consistency reliability and test-retest reliability were assessed. Confirmatory factor analysis (CFA) and multiple-sample invariance tests were performed to test the validity of the PAQ-C in the overall sample and across gender groups. Convergent validity with BMI and an accelerometry-based measure of physical activity were assessed in a subsample of 152 children.

Results: The PAQ-C had good internal consistency (Cronbach's alpha coefficient = .76), item total correlations (all corrected item total correlations > .25) and test-retest reliability (intraclass correlation coefficient = .82). The PAQ-C showed the sensitivity to detect the gender differences. The CFA supported one factor of the PAQ-C which measure only one construct, presumably MVPA during the previous 7 days. The PAQ-C was related to the MVPA measured by accelerometer (r = .34) and inversely related to BMI (r = -.12).

Conclusion: Good internal consistency and test-retest reliability suggest that the PAQ-C is an adequately reliable instrument for use among Chinese children. The

significant moderate correlation between the PAQ-C score with accelerometer measured MVPA support its acceptable validity. The ease-of-use, low cost to investigate and low burden to the participant make the PAQ-C applicable for use in large-scale physical activity studies among Chinese children.

Introduction

There is conclusive evidence that regular PA is positively related to cardiovascular fitness, muscle strength, and lower risk of obesity and diabetes (Paluska & Schwenk, 2000; Warburton, Nicol, & Bredin, 2006). World Health Organization (WHO) has identified physical inactivity as the fourth leading risk factor for global mortality causing an estimated 3.2 million or 6% deaths globally (WHO, 2013). PA and physical fitness track from childhood and adolescence into and throughout the adulthood (Malina, 2001). PA level in childhood has been regarded to as one of the best predictors for PA in later life (Telama, Yang, Laakso, & Viikari, 1997). Valid assessment is crucial to determine relationships between PA and specific health benefits and to valuate PA interventions for children and adolescents.

However, accuracy of PA assessment is inversely related to its practicality. The most accurate measures of PA (e.g., indirect calorimetry) are considered invasive and impractical for field-based studies. Accelerometry-based assessments are accurate, but too expensive for use in larger populations, and face adherence issues (i.e., discomfort to wear, forgetting to wear the device, social embarrassment, or students' laughing), especially among children (Corder, Brage, & Ekelund, 2007). Self-report questionnaires remain the most widely accepted and used methods in large populations due to their low cost to investigate and low burden to the participant. Moreover, contextual items on questionnaires provide information regarding type of activities which is not easily captured through objective measurement (Matthews & Welk, 2002).

Validated self-reported physical activity measures are limited for Chinese pediatric populations. A Chinese 7-day physical activity recall questionnaire, tested among 92 4-6th

grade children in Beijing, demonstrated acceptable test-retest reliability (kappa value ranged from .46 to .79) but moderate validity only among boys (*r* was .46, .38 for different activities) (Liu, Ma, Zhang, & Ma, 2003). A modified Chinese version of the Children's Leisure Activities Study Survey (CLASS) determined reliable estimates of PA patterns among Hong Kong Chinese children aged 9 to 12 years (Huang, Wong, & Salmon, 2009). However, the correlation with the accelerometer measure for validity was non-significant for boys. Both these questionnaires require reports of frequency (times) and duration (min). However, children may have trouble recalling the frequency of activities and have limited ability to accurately report the duration of specific activities (Hussey, Bell, & Gormley, 2007). The memory and estimation biases in PA questionnaires have to be reduced to acceptable level for children (Kremers, Visscher, Seidell, van Mechelen, & Brug, 2005).

The Physical Activity Questionnaire for Older Children (PAQ-C) has been identified as a potentially valid instrument for use with children and adolescents (Chinapaw, Mokkink, van Poppel, van Mechelen, & Terwee, 2010). The PAQ-C is a self-administered, 7-day recall questionnaire for children aged 8 to 14 years consisting of ten items, nine of which are structured to discern MVPA, using a 5-point Likert scale with higher scores indicating higher PA levels (Kowalski, Crocker, & Faulkner, 1997). The last item identifies whether sickness or other events prevented the child from participating in their regular PA, and is not included in the calculation of the activity scores. Of the nine computable PAQ-C items, the first provides a checklist of 22 common leisure and sport activities, followed by two blank supplemental spaces for other activates not included in the list. The score for this question is calculated as the mean for all the

activities. The remaining eight questions assess activities conducted at particular segmented times during the day (e.g. physical education (PE) class, recess, lunchtime, after school, evening, weekends) or day of week summary. The overall score of the PAQ-C is a composite value that calculates the mean of the nine items scores.

The PAQ-C has been tested among several English speaking populations i.e. British, African American, European American, and Canadian (Janz, Lutuchy, Wenthe, & Levy; Moore et al., 2007; Thomas & Upton, 2014). Good internal consistency (Cronbach's α = .76 to .84) and test-retest reliability (r = .75 to .82) have been documented. Its construct validity has been tested against other questionnaires, as well as convergent validity tested against cardiovascular fitness (Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997; Kowalski et al., 1997). Inconsistent validation findings suggest the PAQ-C requires refinement before use with diverse racial groups (Moore et al., 2007). Language and cultural differences also affect an English language questionnaire when translated into Chinese (Deng et al., 2008). Although the Chinese version of the PAQ-C has been applied to measure self-reported PA in China (Chu, 2005; Lau, Lam, Leung, Choi, & Ransdell, 2012), no existing study has assessed the reliability and validity of the Chinese version.

This study tests the properties of the PAQ-C in Chinese children. The general score psychometrics, factor structure using confirmatory factor analysis (CFA), and its convergent validity with BMI and an objective accelerometer measure of PA are examined and reported.

Methods

Participants

A total of 506 students (273 boys and 233 girls) aged 8 to 13 years were recruited from Grades 4-6 in three Hong Kong primary schools from May to June 2014. The schools were located in two Hong Kong districts (New Territories and Hong Kong Island), which varied in student socio-economic status. Students with incomplete data, or who reported sickness or other events preventing them from participating in their usual activities, during the previous 7 days, were excluded.

A subsample of 199 children (105 boys and 94 girls) participated in the 7-day accelerometer protocol. The study was approved by the Hong Kong Baptist University Committee on the Use of Human and Animal Subjects in Teaching and Research.

Measures

Physical activity measured by the PAQ-C

The translation of the questionnaires from English to Cantonese consisted of three separate forward translations by native speakers of the target language, and subsequently back translated by English speakers. Discussion with the local experts in sport and exercise disciplines on the cultural adaptations to the list of activities, “ice skating” was combined with “in-line skating” and “football” with “soccer”. Uncommon activities were removed (street hockey, cross-country skiing and ice hockey/ringette), while five activities regular conducted by Hong Kong Children (squash, tennis, table tennis, hiking, and martial arts (taekwondo, Judo, Kung fu etc.)) were added. Prior to data collection, five Hong Kong Chinese students were invited to test the comprehensibility of the

questionnaire (Drennan, 2003). Minor wording revisions were made based on their feedback.

Physical activity measured by accelerometer

ActiGraph accelerometers GT3X (AG: Actigraph LCC, Fort Walton Beach, FL) were used to assess the convergent validity of the PAQ-C. AGs have been widely used to objectively measure PA level and have demonstrated high reliability and validity among children (Puyau, Adolph, Vohra, & Butte, 2002; Trost et al., 1998). The acceleration of PA is recorded by piezoelectric transducers and microprocessors into digital signals 'counts' at pre-selected epochs. In the present study, 5-sec epochs were set. Activity counts were summed as per minute interval. Based on recent recommendations (Trost, Loprinzi, Moore, & Pfeiffer, 2011), cut-off points developed by Evenson et al. (2008) were used to determine the intensity of moderate physical activity (MPA $\geq$ 2296 counts per min) and vigorous physical activity (VPA, $\geq$ 4012 counts per min) in children. Children were asked to wear AGs for 7 consecutive days. For analysis, extreme values (> 20000 counts per min) were removed. No less than 8 hours of valid wearing time with no more than 20 minutes consecutive zeroes were recognized as a valid day. After one-week of wearing, children could provide a minimum of 4 valid days (3 weekdays and 1 weekend day) were included in the final analysis (Esliger, Copeland, Barnes, & Tremblay, 2005).

Body mass index (BMI)

BMI was calculated as weight in kilograms divided by height in meters squared. Weight and height were taken from the latest records which were measured by PE

teachers in the middle of each semester. Height was measured to the nearest 0.1 cm and weight to the nearest 0.1 kg.

Procedures

The PAQ-C was delivered to students during school time in their class. Children completed the questionnaires under the supervision of the teachers and researchers. Prior to the data collection, verbal assent was obtained from all children. At the beginning of testing, a research assistant gave a brief explanation about the requirements for completing the PAQ-C and about the concept of MVPA, which refers to activities such as "sports or dance that make you sweat or make your legs feel tired, or games that make you breathe hard like skipping, running, climbing and other similar activities" (Crocker et al., 1997). At least one research assistant was available to clarify any aspect of the questionnaires that were required at the time of questionnaire completion. Of all the participants, a subsample of 94 children (51 males and 43 females) was randomly selected to be assessed twice (7-10 days later) to explore the test-retest reliability of the PAQ-C. The questionnaire completion was repeated as described above. The 7-10 day interval was considered most feasible for all schools' schedules, and also considered a reasonable and acceptable period to ensure that children could not remember the questionnaire in great detail (Paiva et al., 2014).

On the day of testing, children attended the accelerometer protocol were gathered in the school hall where the PAQ-C was administered. During the completion of the PAQ-C, a research assistant distributed the AGs to students and they were asked to wear the device positioned on the right hip for 7 consecutive days during waking hours. The accelerometer could only be removed during water-related activities (swimming,

showering, and bathing) and while sleeping, and any removal was to be recorded in the PA diary given to the students. The diary was used to improve compliance to wearing the accelerometers. Additionally, investigators created a WhatsApp group with the students' parents and asked for their assistance via the WhatsApp group, to remind their children to wear the device each day.

Statistical analyses

Means and standard deviations (SD) were calculated for the male, female and combined samples on individual items and total PAQ-C scores. Cronbach's alpha coefficient (Cronbach's α) was computed for the reliability analysis, with values greater than .70 deemed acceptable for general research purposes (Cronbach, 1951). The item/scale relationships were examined by corrected item total correlations (CITCs), which calculated the correlation coefficients between the scores on the items and the sum of scores on all the other items. The items were considered to be inter-correlated with the composite of the remaining items with the level over .30 (Nunnally & Bernstein, 1994). Multivariate analysis of variance (MANOVA), adjusted for age, was used to examine the gender differences of items 1 to 9. Analysis of gender differences in the overall PAQ-C score was tested by an independent *t* test. The intraclass correlation coefficient (McGraw & Wong, 1996) (two-way random model) was computed to determine test-retest reliability. The spearman correlation coefficient *r* was examined to evaluate the convergent validity of the PAQ-C with BMI and the objective PA measures. All these statistical analyses were performed using SPSS version 22.0 (Statistical Product and Service Solutions, developed by IBM corporation) and a two-tailed p value $< .05$ was considered statistically significant.

CFA was performed using the Mplus (Version 7.2) (Muthén & Muthén, 1998-2014) to confirm the one-factor structure of PAQ-C. The model estimation was evaluated by four widely used indicators: the chi-square statistic (χ^2), the comparative-fit index (CFI), Tucker-Lewis index (TLI), and the root-mean-square effort of approximation (RMSEA). A small chi-square statistic relative to the degrees of freedom, resulting in a significant statistic, was considered as goodness of fit (even though it is sensitive to sample size). Criteria of model fit indices developed by Hooper and colleagues (2008) were applied in this study: CFI / TLI > .95 (great), > .90 (good); the root-mean-square error of approximation (RMSEA) < .05 (good), < .08 (acceptable). In addition, the factorial invariance of the PAQ-C score across children's gender groups was evaluated using a multistep approach. The following models were run: configural invariance (no equality constraints), metric invariance (equal item loadings), strong invariance (equal item loadings and item intercepts concurrently), and strict invariance (equal item loadings, item intercepts and item error variance concurrently) (Gregorich, 2006). The difference between two multi-sample models (e.g., configural and metric) was judged based on the difference of CFI value. A value equal to or less than .010 indicates no difference between models and of equality constraints (Cheung & Rensvold, 2002).

Results

Descriptive statistics of the PAQ-C score

Eleven students did not provide complete data and 26 children reported sickness or other events which prevented them from participating in their usual activities during the previous week. This resulted in a final sample size of 469 children (253 males and 216

females, mean age 10.8 ± 1.0 yrs). No gender or age differences were found between the excluded and retained participants. Table 3.1 presents the descriptive statistics for the PAQ-C individual items, summary scores for males, females and the overall sample. The means of the PAQ-C summary score for the whole sample was 2.58 (SD*:* 0.62). Most items had adequate variance and their means were close to the center of range of values. Two items (checklist and lunchtime) had relatively low means with the values of 1.89, 1.67.

Table 3.1. Description of item scores for male, female, and the combined sample

Item	Male (n = 253)		Female (n = 216)		Overall (n = 469)	
	Mean	SD	Mean	SD	Mean	SD
Checklist Q1*	1.97	0.77	1.80	0.70	1.89	0.74
PE class Q2	4.10	0.95	3.91	0.95	4.01	0.95
Recess Q3*	2.26	1.28	1.89	1.05	2.09	1.19
Lunchtime Q4*	1.81	1.14	1.51	0.86	1.67	1.03
Describes best Q5*	2.96	1.22	2.58	1.11	2.79	1.19
After schools Q6	3.02	1.11	2.87	0.99	2.95	1.06
Evenings Q7	2.09	1.26	2.18	1.17	2.13	1.22
Weekends Q8*	3.05	1.18	2.78	1.07	2.93	1.14
Weeks summary Q9	2.79	0.90	2.63	0.84	2.71	0.88
PAQ-C*	2.68	0.62	2.47	0.60	2.58	0.62

Note: SD, Standard deviation; *, significant differences with genders ($p < 0.05$).

Table 3.2. Corrected item total correlations and factor loading for the PAQ –C (n = 469)

Item	CITCs	Standardized factor loading
Checklist Q1	.50	.57
PE class Q2	.40	.46
Recess Q3	.27	.21
Lunchtime Q4	.25	.19
Describes best Q5	.55	.63
After schools Q6	.52	.61
Evenings Q7	.37	.47
Weekends Q8	.52	.66
Weeks summary Q9	.69	.84

Note: CITCs, Corrected item total correlations.

Scale internal reliability and corrected item total correlations

The internal consistency coefficient (Cronbach's α) was .76 for the combined sample. Examination of the recess and lunchtime items demonstrated the lowest corrected item total correlations with a value of .27 and .25, respectively. The remaining items ranged from .37 to .69 (Table 3.2).

Factorial validity in all participants and across gender samples

The standardized factor loading of the PAQ-C ranged from .19 to .84 ($t_s > 2.68$, $p_s < .004$) (Table 3.2). Results of CFA indicated the one-dimension structure of the PAQ-C was a good fit for the data, $\chi^2_{(26)} = 52.14$, TLI = .963, CFI = .973, RMSEA = .046 (90%CI: .028-.064) (Table 3.3).

Cronbach's α were .73 for males and .78 and females. Results of CFA cross gender subsamples indicated the one-dimension structure of the PQA-C was a good fit for males and females (male sample: $\chi^2_{(26)} = 46.80$, TLI = .938, CFI = .955, RMSEA = .056 (90%CI: .029-.082); female sample: $\chi^2_{(26)} = 30.91$, TLI = .987, CFI = .990, RMSEA = .030 (90%CI: .000-.064). The multistep invariance tests also provided reasonably good fit to the data across gender (ΔCFI between configural and metric) was less than .010) (Table 3.3). Gender differences examined by MANOVA, adjusting for age, were significant on PAQ-C items 1, 3, 4, 5, 8, 9 (Wilks Lambda = .92, $p < .001$). Males were significantly more active than females with a higher level of PAQ-C summary score ($t_{(467)} = 3.62$, $p < .001$) (Table 3.1).

Test-retest reliability

Of 94 students who participated in the retest, 1 girl reported sickness and another girl did not provide complete data. The remaining 92 children (51 male, 41 females) were

included in the final analysis. The test-retest reliability was evaluated by examining the intraclass correlation coefficient, which was .82 for the whole sample, .80 for males and .84 for females.

Table 3.3. Fit indices for cross-gender samples of the PAQ-C

	χ^2	DF	*p*	CFI	TLI	RMSEA	90% CI	SRMR	AIC	ΔCFI
All participants	52.14	26	.002	.973	.963	.046	.028-.064	.034	11323.86	
Multi-group Process (cross-gender)										
Configural invariance	77.71	52	.012	.974	.963	.046	.022-.066	.040	11280.73	
Metric invariance	83.94	60	.022	.975	.970	.041	.016-.061	.047	11270.96	.001
Strong invariance	107.94	68	.001	.959	.956	.050	.031-.067	.059	11278.96	-.016
Strict Invariance	167.60	77	< .001	.907	.913	.071	.056-.085	.093	11320.62	-.052

Note: DF, Degree of freedom; CFI, The comparative-fit index; TLI, Tucker-Lewis index; RMSEA, The root-mean-square effort of approximation; CI, Confidence interval; SRMR; ΔCFI, Change in the comparative-fit index.

Convergent validity

Of 199 subsample attended the accelerometer protocol, 6 students were excluded due to the missing data, sickness and other events that prevent them from engaging in regular PA during the previous week. Forty-one children (21.2%) did not provide valid accelerometer data. The final sample consisted of both males (n = 78) and females (n = 74) aged 8-13 year (mean (SD): 10.6 (1.1)). There were no significant age and gender differences for the excluded participants and those retained.

Table 3.4 presents the convergent validity by accessing the correlations between the PAQ-C with BMI and objective PA measures. The correlation between the summarized PAQ-C score and BMI was significant in males (r = -.11, p = .025), females (r = -.13, p = .019) and overall sample (r = -.12, p = .020). PAQ-C score were significantly

correlated with MVPA measured by accelerometer in males (r = .37, p = .001), females (r = .26, p = .034) and all children (r = .34, p < .001).

Table 3.4. Correlations between the PAQ-C score and PA measures (n = 152)

	Description		Correlation		
	Mean n = 152	SD n = 152	Overall n = 152	Males n = 78	Females n = 74
BMI (kg/m^2)	18.49	3.59	-.12*	-.11*	-.13*
Objective PA					
Total MPA (min/day)	28.31	9.65	.26**	.32**	.21*
Total VPA (min/day)	12.70	6.07	.36**	.39**	.29*
Total MVPA (min/day)	41.00	14.44	.34**	.37**	.26*

Note: * p<.05, ** p<.01.
BMI, Body mass index; MPA, Moderate physical activity; VPA, Vigorous physical activity; MVPA, Moderate-to-vigorous physical activity;

Discussion

To the best of our knowledge, this is the first PAQ-C validation study among Chinese children aged 8-13 years. Good internal consistency, test-retest reliability, and moderate convergent validity with the accelerometry-based measures have provided evidence that the PAQ-C is a valuable measurement tool for large PA assessment studies with Chinese children.

CICTs were performed to check if the individual item was measuring the same construct by evaluating the correlation between the corresponding item score with the others in the set of scale. CITCs have been recommended to exceed .30 (Nunnally & Bernstein, 1994). There were two items (.27 for recess and .25 for lunchtime PA) were slightly lower than the recommended level. However, there was no significant improvement on the scale internal consistency if the items were deleted. Furthermore, in

the similar questionnaire validation studies, several studies adopted the CITCs value of .20 as the standard for item removal (Bagby, Taylor, Parker, & Dickens, 2005; Howells et al., 2009). Considering the requirements of the factor analysis, two items were retained. Cronbach's α over .70 is usually considered an indication of a reliable questionnaire. The fact that Cronbach's α was .76 for the combined sample suggests good scale consistency in Hong Kong Chinese children. Additionally, the current findings revealed ICCs higher than .80 for both genders, which is strong evidence to support the test-retest reliability of the PAQ-C in this target population.

The means of most of the individual items were close to the center of the range and their adequate variability indicates the discrimination of activity among subjects. The exceptions were the checklist and lunchtime PA. The low score of checklist was attributed to the fact that individuals may not participate in the large number of listed activities. The findings of small score on lunchtime PA indicate that Hong Kong primary school children's low engagement in PA during these school segments, which was consistent with previous studies (Chow, McKenzie, & Louie, 2008; Johns & Ha, 1999). One observation study has pointed out that school recess-based activity in Hong Kong is limited with sitting accounted for 23.3% of the observation time, while standing accounted for 40.5% among students (Johns & Ha, 1999). In Hong Kong, school policies do not encourage students to engage in activities during lunchtime (Chow et al., 2008; Johns & Ha, 1999). Students are asked to stay in class after their lunch to watch teaching videos together or to do their homework, and are not permitted to run during these segments in order to avoid possible injuries. Low PA level in Hong Kong children can also possibly be attributed to a short lunchtime (approximately 25-30 min). Furthermore,

schools in Hong Kong are generally small and are situated in high-density buildings, and a lack of outdoor play space ($2m^2$ per student) may limit children's activity during recess (Department of Education of Hong Kong, 2000). This result highlights the necessity for further studies to quantify the PA levels of children during lunchtime and to examine their contribution towards PA guideline.

The combined group presented with the summarized PAQ-C score of 2.58 (SD: 0.62), which is lower than that in the studies among different racial groups of children, i.e., 3.49 (SD: 0.68) in British samples (Thomas & Upton, 2014), 3.36 (SD: 0.80) for European American children, and 3.37 (SD: 0.69) in African American children (Moore et al., 2007). In two additional validation studies, summary scores of over 3.20 were reported (Crocker et al., 1997; Kowalski et al., 1997). Consistent with previous PA level assessment studies, the finding from the current study further reveals that Hong Kong children demonstrated a lower PA pattern than their counterparts from other countries (Macfarlane, 1997; Mak & Day, 2010; So et al., 2010). This finding calls for the imperative action to improve PA among Hong Kong Children.

One-factor model in the PAQ-C was adopted and the results of CFA suggest one-factor model was appropriate, which indicate the questionnaire measure only one construct, presumably MVPA during the previous 7 days. This finding was consistent with the study of Janz and colleagues (2008). Similar to the Pearson correlation, the standardized regression coefficient of each item was regarded as the predicting indicator for the construct of questionnaire. The significant standardized regression coefficients ranged from .19 to .84 suggested the acceptable correlations between the items and the scale measure. Additionally, by using the multiple step approach, this study demonstrated

the good model fit both in male and female subgroups. The ΔCFI value between configural and metric invariance was less than .010, which indicated no difference between models across gender and thus tenability of equality of constraints. The PAQ-C has demonstrated the sensitivity to detecting the gender differences within Hong Kong children population. Boys as a group (mean (SD): 2.68 (0.62)) reported more PA than girls (mean (SD): 2.47 (0.60)).

To estimate the degree to which any two measures are related to each other, the convergent validity is generally performed using correlation coefficient. The convergent validity is supposed that the measures should be related are in reality related. In the current study, convergent validity was assessed by testing the extent to which the PAQ-C related to BMI. It is known that PA is a key component in weight control. Substantial evidences have shown that overweight and obese children are less physically active than their peers with normal body weight (Frank, Andresen, & Schmid, 2004; Molnar & Livingstone, 2000). This study found an inverse relationship between PAQ-C and BMI (*r* was -.11 for males, -.13 for females, and -.12 for overall samples), which supports the fact that children with higher BMIs are likely to participate in less PA (Janssen et al., 2005). The magnitude of association between the PAQ-C score with BMI is comparable with previous validation study ($r = -.16$) (Moore et al., 2007).

Accelerometers monitor PA by recording the acceleration of human movement and this measure has been used as the criterion reference to detect intensity and quantity of movement (Janz, 1994). The convergent validity of the PAQ-C was further evaluated by calculating the correlation between the PAQ-C and accelerometer determined PA measures. Moderate correlations were observed between the PAQ-C summary score and

MVPA for boys (r = .37) and for the overall sample (r = .34). A slightly lower but significant correlation (r = .26) was found for girls. The correlation coefficients were similar to previously reported associations between the PAQ-C and PA measured by the Caltrac activity monitor (r = .39) (Kowalski et al., 1997). The magnitude of correlation that we report are also similar to other PA recall questionnaires for children presented when compared with objective PA measures. For example, in the study of Welk et al. (Welk et al., 2007), the correlation coefficient is .24 for the Youth Media Campaign Longitudinal Survey (YMCLS) in the estimates of weekly PA. Sallis et al. (Sallis, Buono, Roby, Micale, & Nelson, 1993) reported the validity coefficient of .33 and .29 with heart rate ≥ 140 bpm and ≥ 160 bpm for the Seven-Day Physical Activity Recall (PAR) among fifth grade students. For 1-day to 3-day recalls in children, the correlation was found with .32 for the previous day Self-Admin PA Checklist (SAPAC) (Sallis et al., 1996), .35-.43 for the Previous Day Physical Activity Recall (PDPAR) (Trost, Ward, McGraw, & Pate, 1999), .27-.46 for the 3-Day Physical Activity Recall (3DPAR) (Pate, Ross, Dowda, Trost, & Sirard, 2003), and .22 for the 3-Day Aerobic Recall (Janz, Witt, & Mahoney, 1995). The validity results in the current study are also comparable with other convergent studies evaluated using step tests in European American children (r = .30) (Moore et al., 2007), and the ½ mile walk-run test (r = -.37) in British children (Thomas & Upton, 2014).

Several limitations of this study warrant consideration. The PAQ-C was designed for children aged 8-14 years. However, despite the fact that the age range of children recruited in the current study was 8-13 years, the proportion of younger children at the 8 years old was low, which may limit the generalizability of the results for early

adolescents. Considering the comprehensibility of younger children, additional studies are needed to examine the suitability of the PAQ-C among the pediatric population in this age group. Secondly, regarding the convergent validity of the PAQ-C with BMI, the latest records of participants' height and weight from PE teachers were used rather than those measured by researchers during testing, this may slightly affect the findings. Additionally, even accelerometer is considered both accuracy and feasibility when assessing PA in population. There are several reliability issues regarding the application of this measure. In the current study, we estimated the activity level on a minute-to-minute basis. Actually, human activity can take place on a various time scale. Different cut-points may provide different time spent on MVPA and consequent magnitude of association between PAQ-C and accelerometer-based MVPA. Accelerometer also has the limitation to measure upper limb and water-related activities and has the potential to underestimate children's PA level. Compliance issue (e.g., forget to wear, unwilling to wear, shake the device to get a higher value) is a great concern in young population. This call for further validation studies between PAQ-C and other more accurate methods (e.g., double labelled water, indirect calorimetry). Finally, the sample size for accelerometer protocol was relatively small for a validation study, and any bias resulting from this small simple size may influence the results. Therefore, further research is required with larger populations.

Conclusion

This is the first reported validation study of the Chinese version of the PAQ-C. Results suggest good item and test score characteristics and a reasonable one-factor

structure. Good internal consistency and test-retest reliability indicate that the PAQ-C is an adequately reliable instrument for use with Hong Kong children. The significant moderate correlation between the PAQ-C summary with MVPA assessed by accelerometer supports its acceptable validity. In conclusion, although the PAQ-C is limited in its ability to provide information on PA frequency, intensity and duration, its ease-of-use and administration, low cost to investigate and low burden to the participant make the PAQ-C applicable for use in large-scale PA studies with Chinese children.

Given the epidemic of physical inactivity in China, understanding the association between psychological correlates and PA behavior could inform future development of more efficacious interventions. The following chapter aims to explore the associations among self-efficacy, motivation, preference and PA in Chinese children, which would be helpful to identify predictors when assessing the subsequent intervention effect.

Chapter 4 Study 2: Association between Psychological Correlates with Physical Activity among Chinese Children: A Cross-sectional Study

Abstract

Background: Given the epidemic of physical inactivity in China, understanding the association between psychological correlates and PA behavior could inform future development of more efficacious interventions. This is one of the first studies to explore the associations among self-efficacy, motivation, preference and PA in Chinese children. Additionally, this study sought to examine if these associations varied by different methods of assessing PA, controlling for social desirability.

Methods: PA self-efficacy, motivation, and preference were reported in a cross-sectional sample of 301 children (178 males, 123 females) aged 8 to 12 years living in Hong Kong. Children's MVPA was measured with an accelerometer and by the PAQ-C. Bivariate Pearson correlations were computed to explore the relationships among study variables. Hierarchical regression was performed to evaluate the relationships among psychological correlates and both self-reported and objectively assessed MVPA.

Results: PA self-efficacy, preference, autonomous and controlled motivations were all positively related to PAQ-C score and objective MVPA with correlation coefficients ranging from .17 to .61 in size (p_s < .01). The relationships with PAQ-C were all substantially stronger than those with accelerometry. PAQ-C and objective MVPA correlated at r = .33. The addition of the psychological correlates accounted for 52% of the variance of PAQ-C score beyond that accounted by demographics and social desirability, while they increased explained variance by only 10% of objectively assessed

MVPA. The specific variables predictive of PAQ-C score (age, PA self-efficacy, autonomous motivation and preference) were somewhat different from those predictive of objective MVPA (PA self-efficacy and autonomous motivation, and negatively predicted by gender).

Conclusions: This study demonstrated the important effects of self-efficacy and autonomous motivation in predicting PA. Although these prediction differed for self-reported and object PA, which is likely due to self-reported error variance common to the PAQ-C and psychological correlates but not to accelerometry, the findings of this chapter were considered helpful in order to identify predictors when assessing the subsequent intervention effect.

Introduction

The health benefits of regular PA in children have been well documented, including reduced body fat, enhanced physical fitness and bone health, more favorable cardiovascular risk profiles, and decreased symptoms of anxiety and depression (Janssen & LeBlanc, 2010). In addition, PA positively influences children's academic performance (Singh, Uijtdewilligen, Twisk, Van Mechelen, & Chinapaw, 2012). Current PA guidelines recommend children aged 5-17 years participate in at least 60 minutes of MVPA on a daily basis (WHO, 2010). Despite considerable evidence supporting the PA's protective effects, physical inactivity remains widespread (Heitzler et al., 2011; Kimm et al., 2002). A national survey using accelerometers revealed that Chinese children and youth spent an average of 28.3 minutes per day in MVPA. Only 9.4% of boys and 1.9% of girls met the recommendation of 60 min/day of MVPA (Wang, Chen, & Zhuang, 2013). Similarly in Hong Kong, only 8.3% of children aged 7-12 years engaged in the recommended PA levels (Leisure and Cultural Services Department of Hong Kong, 2012). From a public health perspective, increasing children's PA levels is especially important.

Given the epidemic of physical inactivity in China, understanding the association between psychological correlates and PA could inform the development of more efficacious interventions. SDT (Deci & Ryan, 1985) is an appealing theoretical framework for understanding how motivational factors may relate to PA and has been widely employed (Deci & Ryan, 2000). SDT posits that motivation helps individuals initiate and maintain behavior. SDT offers a motivational sequence ranging from low to high levels of self-regulation underpinning PA, known as amotivation (i.e. lack of

intentionality and personal causation), external regulation (i.e. external locus of initiation, e.g., for gaining reward or avoiding punishment), introjected regulation (i.e. involving internalized rules or demands), identified regulation (i.e. realizing the value of behavior and accepting the regulatory process), and intrinsic motivation (i.e. inherent satisfaction in doing the behaviors) (Ryan & Deci, 2000). Based on these different motivational regulations, SDT distinguishes the autonomous and controlled motivations. Intrinsic motivation and identified regulation are considered autonomous forms of motivation because they reflect a sense of personal volition and originate from an internal perceived locus of causality. Alternatively, introjected and external regulations are considered controlled motivation to reflect external demands, originating from an external perceived locus of causality (Deci & Ryan, 2002).

SDT provides valuable insight into how to foster increments in autonomous motivation, indicating that more self-determined forms of motivation lead to optimal functioning and well-being (Ryan & Deci, 2007). A review of forty-six studies of the association between the motivations and PA in children and adolescents indicated that autonomous motivation had moderate positive association with PA (ρ = .27 to .38), whereas controlled forms of motivation had weaker negative associations with PA (ρ = -.11 to -.21) (Owen, Smith, Lubans, Ng, & Lonsdale, 2014). Most of these existing studies, however, targeted western populations. One study among Hong Kong Chinese students found differences in PA levels between high and low self-determined groups (Lonsdale, Sabiston, Raedeke, Ha, & Sum, 2009). Two PA motivation studies were conducted in Mainland China and Tai Wan (Pan, Tsai, Chu, & Hsieh, 2011; Wang, Liu, Sun, Lim, & Chatzisarantis, 2010), but were specifically conducted in physical education contexts.

There is a paucity of research on PA motivation among underserved Chinese children in free living conditions. Considering the obvious western vs Chinese cultural differences (e.g., heavy homework load and emphatic pressure on academic performance among the Chinese), perceived balance between PA and school work might not influence Chinese children's intentions and decisions to be physically active (Zhang, Middlestadt, & Ji, 2007). Thus, studies of Chinese children's motivational correlates of daily PA are imperative.

SCT (Bandura, 1986) integrates individual cognitive and environmental influences to predict behaviors. SCT focuses on self-regulation processes and reciprocal determinism, i.e., determinant interaction. Self-regulation processes emphasize self-efficacy beliefs which are the self-confidence that people have to engage in behaviors such as PA (Norman & Connor, 2005). Self-efficacy was a significant positive predictor of exercise adherence (McAuley & Blissmer, 2000). Limited research has examined the relationship between self-efficacy and PA in Chinese pediatric populations in China Mainland (Li, Dibley, Sibbritt, & Yan, 2006; Murnan, Sharma, & Lin, 2007), Taiwan (Wu, Pender, & Noureddine, 2003; Wu & Pender, 2002), and Hong Kong (Huang, Wong, & Salmon, 2013). Preference for the behavior, a component of behavioral choice theory (Epstein, 1998) has been applied to explain PA behavioral choice. Preference for PA was a significant predictor of engagement in PA in a large community-based sample of adults (Salmon, Owen, Crawford, Bauman, & Sallis, 2003). Clustering of activity preferences was identified in primary school children (Rodenburg, Oenema, Pasma, Kremers, & van de Mheen, 2013), with higher preference or liking for sedentary behavior negatively associated with time spent in a free-choice situation (Epstein, Saelens, Myers, & Vito,

1997). However, few studies have assessed the relationship between children's PA preference with active behaviors. Given inherent limitations and bias in self-reported measures of PA (Trost, 2007), research is needed using more objective accelerometry, which is paramount to our attempts to better exploring the correlates of actual PA behaviors.

This study aims to assess the relationships among self-efficacy, preference, motivation and PA in Chinese children. Children's PA was measured with both an accelerometer and self-reported recall to access the possible differences in these relationships. Since previous studies found that Social desirability (SocD), the self-report bias of overestimating desirable behaviors and underestimating undesirable ones, influenced self-reports of PA as a source of error (Adams et al., 2005; Dadds, Perrin, & Yule, 1998; Klesges et al., 2004), SocD was measured and statistically adjusted in the current study.

Methods

Participants

Participants were recruited from six primary schools in two Hong Kong districts, which had varied socio-economic backgrounds. Informed written consent was obtained from all parents (or guardians) prior to data collection. Students with any contraindication to PA, physical disease (heart, lung, liver, kidney, other vital organs, endocrine diseases or drug side effects), or psychological illnesses that may have prevented them from participating in PA were excluded. A total of 301 students aged 8 to 12 years (178 males, 123 females) were recruited from Grades 4-6. The study was approved by the

Institutional Committee on the Use of Human and Animal Subjects in Teaching and Research of Hong Kong Baptist University.

Procedures

The translation of the questionnaires from English to Cantonese Chinese consisted of three separate forward translations by native speakers of the target language, and subsequently back translated by English speakers. Prior to data collection, five Hong Kong Chinese students were invited to test the comprehensibility of the Cantonese questionnaire (Drennan, 2003). Minor wording revisions were made based on their feedback. On the testing day, height and weight were measured and questionnaires were delivered to students. During the completion of the questionnaires, research assistants distributed the ActiGraph to students.

Measures

Height, weight and BMI

Height was measured to the nearest 0.1 cm using a calibrated FISCO measuring tape (CMS Weighting Equipment Ltd, London, UK) and weight was measured to the nearest 0.1 kg using a Tanita electronic digital scale (Model No. HD305, Tanita Inc, Tokyo, Japan) complying with standard anthropometric methods (Cameron, 1978). BMI (kg/m^2) was calculated as weight divided by height squared.

Objective PA behaviors

Objective PA was measured using ActiGraph GT3X accelerometers (AG: ActiGraph LCC, Fort Walton Beach, FL), which have demonstrated high reliability and validity among children (de Vries, Bakker, Hopman-Rock, Hirasing, & van Mechelen, 2006). Students were asked to wear the device positioned on the right hip for 7 consecutive days

during waking hours. The accelerometer could only be removed during water-related activities (swimming, showering, and bathing) and while sleeping, and any removal was to be recorded in the PA diary given to the students. The diary was used to improve compliance to wearing the accelerometers. AG is a small, lightweight, and unobtrusive triaxial device that measures acceleration into activity counts and step counts at pre-selected epochs. In the present study, 5-sec epochs were set. Activity counts were summed as per minute interval. For analysis, extreme values (> 20000 counts per min) were removed. No less than 8 hours of valid wearing time with no more than 20 minutes of consecutive zeroes were recognized as a valid day. After one-week of wearing, children who could provide a minimum of 3 valid days were included in the final analyses (Esliger et al., 2005). Based on recent recommendations (Trost et al., 2011), cut-off points developed by Evenson et al. (2008) were used to determine the intensity of moderate (≥ 2296 counts per min) and vigorous PA (≥ 4012 counts per min) in children.

Self-report PA behaviors

Self-reported PA was measured using the Physical Activity Questionnaire for Older Children (PAQ-C) (Kowalski, Crocker, & Faulkner, 1997), validated for use with children and adolescents (Chinapaw et al., 2010). PAQ-C includes ten items, nine of which are used to compute MVPA for the day as a whole and for segments during the day (e.g. physical education class, recess, lunchtime, after school, evening, weekends) or day of week using a 5-point Likert scale. The reliability and validity of the PAQ-C have been documented in Chapter 3 (page 55-74).

PA self-efficacy

PA self-efficacy was assessed using a modified 12-item scale developed by Jago and colleagues (Jago et al., 2009). Example items included "How sure are you that you can be physically active more than 30 minutes for one day, even when you have homework?" "How sure are you that you have the ability to do physical activities like running, dancing, bicycling, or jumping rope?" (1= I am not sure; 2 = I am sure a little; 3 = I am sure a lot). This scale demonstrated good internal consistency (α = .93). To test whether the factor structure was the same as previous work using this scale, a confirmatory factor analysis (CFA) using maximum likelihood estimation was conducted in Mplus (Version 7.2) (Muthén & Muthén, 1998-2014). Fit indices [1] of CFA showed modest fit ($\chi^2_{(48)}$ = 133.76; the comparative-fit index (CFI) = .962; Tucker-Lewis index (TLI) = .947; the root-mean-square error of approximation (RMSEA) = .079) when all 12 items loaded onto one factor of self-efficacy. Construct validity was supported in the current study by significant positive relationship with PA preferences (r = .52, p < .001), PA autonomous motivation (r = .48 with intrinsic motivation and .50 for identified regulation, p_s < 0.001), and MVPA (r = .61 for the PAQ-C and .28 for objectively measured MVPA, p_s < 0.01).

PA preferences

PA Preferences was measured using a validated 28-item scale (Sallis et al., 1996b). Items asked how much children liked the different PA (e.g., bicycling, swimming, dancing, etc.) (1 = I have never done it; 2 = I do not like it; 3 = I like it a little; and 4 = I like it a lot). The 28 items were averaged to create an overall measure of PA preference. This scale demonstrated adequate reliability (α = .86) and construct validity (r = .52 with PA self-efficacy, p < .001; r = .43 with intrinsic motivation, p < .001; r = .40 with

[1] Criteria of model fit indices (Hooper et al., 2008): the comparative-fit index (CFI) /,Tucker-Lewis index (TLI) > .95 (great), > .90 (good); the root-mean-square error of approximation (RMSEA) < .05 (good), < .08 (acceptable).

identified regulation, $p < .001$; $r = .46$ with the PAQ-C, $p < .001$; and $r = .17$ with objective MVPA, $p = .005$). Fit indices [2] of a CFA examining whether items loaded onto one factor of PA preferences showed modest model fit ($\chi^2_{(338)} = 645.34$; CFI = .803; TLI = .780; RMSEA = .064; Standardized root mean square residual (SRMR) = .077).

PA motivation

The motivation for exercise questionnaire consists of 16 items designed to assess an individual's four types of behavioral self-regulation derived from SDT: 3 items for intrinsic motivation, 5 items for identified regulation, 3 items for interjected regulation, and 5 items for external regulation (Deci & Ryan, 2010). Children scored these items for the reasons why they engage in PA by using a 7-point Likert scale (1 = not at all true; 4 = somewhat true; 7 = very true). Example items are: I am active regularly "Because I enjoy being active" (intrinsic motivation), "Because it is a challenge to accomplish my goal" (identified regulation), "Because I would feel like a failure if I was not active" (introjected regulation), "Because others would be angry at me if I was not active" (external motivation). Standardized coefficient alphas in the current sample were .85 for intrinsic, .81 for identified, .71 for introjected, and .71 for external regulation. The score for autonomous motivation ($\alpha = .88$) was created by averaging the items in the subscales of intrinsic motivation and identified regulation, whereas the items under introjected and external regulations were averaged to form a score of controlled motivation ($\alpha = .79$). A CFA was run to examine whether items loaded onto four factors of PA motivation. Fit indices showed modest model fit ($\chi^2_{(93)} = 224.03$; CFI = .927; TLI = .906; RMSEA

[2] The model fit indices of PA preference did not well meet the criteria described above. However, according to Hu and Bentler's two-index presentation strategy (Hu & Bentler, 1999), the mode fit could be considered acceptable if 1) TLI ≥ .96 & Standardized root mean square residual (SRMR) ≤ .09; or 2) RMSEA ≤ .06 & SMMR ≤ .09; or 3) CFI ≥ .96 & SRMR ≤ .09.

= .069). The significant positive relationships between these self-regulation scales and PA self-efficacy, PA preference, PAQ-C, and accelerometry-based MVPA (*r* ranged from .15 to .52, $p_s < .010$) provided evidence for subscale construct validity.

Social desirability (SocD)

SocD was assessed using a nine-item scale (Reynolds & Paget, 1983) with good internal consistency in the current sample (α = .89). CFA indicated the one-dimension structure of SocD was an acceptable fit for the data ($\chi^2_{(23)}$ = 67.74; CFI = .963; TLI = .943; RMSEA = .093). Sample items included "I tell the truth every single time; I never say things I shouldn't" (0 = never true of me; 1 = not sure; 2 = sometimes true of me; 3 = always true of me).

Statistical analysis

Data were input with Epidata3.1 and analyzed with SPSS20.0. Data were screened for outliers and missing values. Descriptive statistics were computed to describe the qualified participants' characteristics. Bivariate Pearson correlations were computed to explore the relationships among study variables. MANCOVA was employed to investigate gender differences in the four types of regulation with adjusting key confounders (i.e., age and BMI). Independent samples *t* tests were calculated to examine gender differences for mean values of PA self-efficacy, preference, and behaviors. Hierarchical regression was performed to evaluate the effects of motivation, self-efficacy, and preference on both self-reported and objective MVPA. For each of two regression analyses, gender, age, BMI and SocD were entered in the first Step, whereas PA self-efficacy, preference, autonomous and controlled motivations were entered in Step 2. The significance of the *F* ratio accompanying the change in variance (R^2) for each step

indicated the significance of the addition of each group of independent variables to the regression equation. If the step was significant, then the standardized coefficients (B), standard error (SE) and *t* values of each independent variable within the regression equation were reported.

Results

Participants' demographic characteristics

Of 301 participants, 8 were excluded due to the missing data or events that prevented them from engaging in regular PA during the previous week. No extreme score was identified. Demographic characteristics for the final data set were comprised of 174 males and 119 females as presented in Table 4.1. Mean age for participants was 9.8 ± 1.0 yr; mean BMI was 19.0 ± 3.9 kg/m^2. Boys had higher BMI than girls ($t_{(291)}$ = 2.87, p = .004).

Table 4.1. Children's demographic characteristics

	Boys (n = 174)	Girls (n = 119)	Total (n = 293)
Age (year)	9.80 (0.98)	9.83 (0.96)	9.82 (0.97)
Height (cm)	141.00 (9.10)	142.45 (9.17)	141.59 (9.14)
Weight (kg)	38.91 (11.03)	37.37 (9.92)	38.28 (10.60)
BMI(kg/m^2)*	19.56 (3.94)	18.25(3.59)	19.02 (3.85)

Notes: Values are presented as means (stand deviations). $^*p < .05$.

Preliminary analyses on psychological correlates and PA behaviors

Descriptive statistics, internal consistency reliability coefficients and bivariate correlations among the psychological correlates and PA behaviors are shown in Table 4.2.

Participants had a PA self-efficacy score of 2.2 (SD: 0.6), and PA preferences score of 2.9 (SD: 0.4). Children endorsed autonomous motivations (5.3 ± 1.5) more highly than controlled reasons (2.9 ± 1.4). Children had low external regulation (2.4 ± 1.4), moderate introjected regulation (3.3 ± 1.7), and relatively high identified regulation (5.0 ± 1.6) and intrinsic motivation (5.6 ± 1.5).

Boys were more physically active than girls using accelerometry-based MVPA ($t_{(244)}$ = 4.66, p < .001). Boys had higher controlled motivations than girls (introjected regulation: $F_{(1)}$ = 4.42, p = .036; external regulations: $F_{(1)}$ = 3.95, p = .042). No significant gender differences were detected on other psychological correlates by MANCOVA or *t* tests (all p > .05).

Moderate correlations were found among self-efficacy, preference, and autonomous motivation (all r > .30, p < .01), while relatively low correlations were found between them and controlled motivation (p_s < .01). External regulation underpinning controlled motivation was unrelated to PA preferences (p = .083). PA self-efficacy, preferences, autonomous and controlled motivation were all positively related to PAQ-C score and objective MVPA with correlation coefficients ranging from .17 to .61 in size (p_s < .01). External motivation was weakly correlated to the PAQ-C score (r = .19, p = .001), but unrelated to objective MVPA (p = .065). The relationships between the psychological correlates and PAQ-C were all substantially stronger than those measured by accelerometer.

Table 4.2. Descriptive statistics, internal reliability coefficients and Pearson correlation coefficients (n = 293)

Variable (range of possible score)	Mean (SD)	α	1	2	3	4	5	6	7	8	9
1. PA self-efficacy (1, 4)	2.17 (0.61)	.93									
2. PA preference (1, 4)	2.88 (0.43)	.86	.52**								
3. Intrinsic motivation for PA (1, 7)	5.56 (1.54)	.85	.48**	.43**							
4. Identified regulation for PA (1, 7)	5.03 (1.63)	.81	.50**	.40**	.76**						
5. Introjected regulation for PA (1, 7)#	3.30 (1.69)	.71	.44**	.34**	.42**	.54**					
6. External regulation for PA (1, 7)#	2.44 (1.41)	.71	.15**	.11	.01	.19**	.53**				
7. Autonomous motivation(1, 7)	5.29 (1.49)	.88	.52**	.44**	.93**	.94**	.51**	.11			
8. Controlled motivation (1, 7) #	2.87 (1.36)	.79	.36**	.27**	.27**	.43**	.90**	.85**	.38**		
9. PAQ-C score (1, 5)	2.73 (0.75)	.78	.61**	.46**	.52**	.47**	.47**	.19**	.53**	.40**	
10. Objective MVPA#	43.32 (14.42)	.73	.28**	.17*	.23**	.25**	.23**	.12	.25**	.21**	.33**

Notes: α, Cronbach's alpha for variable 1-9, intraclass correlation coefficient across days for moderate-to-vigorous physical activity (MVPA, min/day); participants (n = 246) provided valid accelerometer data.
Significant differences between genders, $p < .05$.
*$p < .05$, **$p < .01$.

Table 4.3. Hierarchical multiple regression analyses predicting the PAQ-C score and objectively monitored MVPA (n = 246)

	PAQ-C score					Accelerometry-based MVPA				
	B	SE	*t*	R^2	Δ R^2	B	SE	*t*	R^2	Δ R^2
Step 1				.02					.08	
Age	.02	0.05	0.26			-.06	0.94	-0.81		
Gender	-.02	0.11	-0.27			-.29	1.89	-4.08*		
BMI	-.07	0.01	-0.88			-.03	0.27	-0.43		
Social desirability	.11	0.01	1.44			.02	0.17	0.31		
Step 2				.54	.52**				.18	.10**
Age	.11	0.04	2.13*			-.03	0.92	-0.43		
Gender	-.02	0.08	-0.46			-.29	1.85	-4.12*		
BMI	-.02	0.01	-0.37			-.01	0.26	-0.11		
Social desirability	-.02	0.01	0.38			-.02	0.16	-0.32		
PA self-efficacy	.37	0.08	5.45*			.21	2.00	2.32*		
PA preference	.20	0.11	3.00*			-.01	2.64	-0.03		
Autonomous motivation	.31	0.03	4.88*			.18	0.78	1.99*		
Controlled motivation	.01	0.03	0.08			-.02	0.78	0.31		

Note: B, standardized coefficients; SE, standard error.
*$p < .05$, **$p < .01$

Predicting PA behaviors from age, sex, BMI, social desirability and psychological correlates

Multiple step-wise regression analyses examined whether the psychological constructs correlated with PA behaviors. Only children providing both valid PAQ-C and accelerometer data (n = 246) were included in the regression procedures. As shown in Table 4.3, the demographic characteristics and SocD accounted only 2% of the variance in PAQ-C, while the addition of the psychological correlates accounted for an additional of 52% of the variance. PAQ-C score was positively predicted by age, and PA self-efficacy, preferences and autonomous motivation. In the regression model of MVPA assessed by accelerometer, adding the psychological correlates to the regression model only increased explained variance by 10%. Objective MVPA was positively predicted by PA self-efficacy and autonomous motivation, and negatively predicted by gender (male =1, female =2).

Discussion

This study is among the first to investigate the importance of psychological correlates in understanding PA of Chinese children using both accelerometry and self-reported estimates, and to demonstrate the association varied depending on the different PA measures. Children endorsed autonomous motivation more highly than controlled reasons. In a hierarchical regression model, age, PA self-efficacy, preferences, and autonomous motivation positively predicted self-reported PA after controlling for gender, BMI, and SocD. However, the correlation between external regulation with objectively assessed MVPA was nonsignificant. Age and PA preference did not contribute

significantly in the hierarchical model predicting objectively assessed MVPA which was positively predicted by PA self-efficacy and autonomous motivation, and negatively predicted by gender. The higher correlations with self-reported PA was likely due to shared self-report error variance (Podsakoff, MacKenzie, & Podsakoff, 2012), even though SocD was measured and statistically controlled.

Self-efficacy has been one of the most important correlates of youth PA (Bandura, 2004). The available research on gender differences in self-efficacy for PA in children and adolescents is somewhat inconsistent in Chinese children. Among Taiwanese adolescents, girls reported lower PA self-efficacy than boys (Wu et al., 2003), whereas, no gender difference was detected in the current study and another among Hong Kong Chinese children (Huang et al., 2013). In the current study, PAQ-C and objective MVPA were both positively predicted by self-efficacy in the hierarchical regression procedures. Minutes of PA was predicted by self-efficacy to exercise and number of times taught at school in Chinese children (R^2 = .20) (Murnan et al., 2007). Positive prediction of PA by self-efficacy was also noted in Hong Kong children (Huang et al., 2013), Taiwanese adolescents (Wu & Pender, 2002), and South Korean children (Cho, 2004). Similar to findings among Caucasian children (Plotnikoff, Costigan, Karunamuni, & Lubans, 2013), self-efficacy appears to be an important predictor of PA among Asian cultures.

Higher autonomous motivation (i.e., identified and intrinsic) should be a more consistent predictor of reported behavior than higher externally oriented motivations (i.e., extrinsic and introjected) (Ryan & Deci, 2000). Participants in the current study reported higher levels of autonomous motivation and lower levels of controlled motivation. Congruent with previous studies using SDT (Standage, Sebire, & Loney, 2008;

Thøgersen-Ntoumani & Ntoumanis, 2006), autonomous motivation positively predicted greater PA on both PAQ-C and objected assessed MVPA. This finding suggests that children's PA levels increase as their beliefs that PA is inherently enjoyable and pleasurable and the values they place on PA increases. Theoretically, controlled regulation should be negatively associated with PA (Ryan & Deci, 2007), which also has been reported in the empirical study with exercise behavior (Owen et al., 2014). In contrast to expectation, the positive correlations between controlled motivation and PA were observed in the current study. Introjected regulation, underpinning controlled motivation, was positively related to both self-reported and objectively assessed PA. While this finding departs from the hypothesis, previous studies also found a positive relationship between introjected regulation and PA (Edmunds, Ntoumanis, & Duda, 2006; Standage et al., 2008). This might reflect children's concern for their physique, e.g., the motivation to engage in PA partly to satisfy self-needs and pressure to have a desired body shape and physical appearance (Fogelholm & Kukkonen‐Harjula, 2000). Additionally, introjected regulation appears to have been associated with PA in the short-term, but not the longer term (Pelletier, Fortier, Vallerand, & Briere, 2001; Silva et al., 2011). This implies the need for a persistent emphasis on identifying the value and motivating the enjoyment of the behavior. Health-care professionals could assist people with external or introjected regulation in changing their motivational orientation by setting goals in the context of choice.

This is one of only a few studies that investigated PA preference, which may be key in developing effective PA-promoting and weight-control strategies for children (Jeffery et al., 2000). Preferences for moderate PA accounted for 2.9% of the variance in

moderate PA, but 16.3% of the variance in vigorous PA among adults (Salmon et al., 2003). In the current study, hierarchical regression revealed that PA preference was a positive predictor of PAQ-C, but not for objectively assessed MVPA. Thus, preferences for PA may not be a correlate of PA among Chinese children, which should inform the development of policies and strategies to increase PA and reduce sedentary behavior.

This study examined all day PA, including during school time and after school time, and leisure time PA rather than PA in physical education or other specific settings. Consistent with previous literature, this study demonstrated boys engaged in significantly more objective MVPA than girls (Gao, Wang, Lau, & Ransdell, 2015; Myers, Strikmiller, Webber, & Berenson, 1996; Trost et al., 2002). A notable strength of the current study was use of both accelerometer and self-reported measures of PA. Although SocD bias was measured and controlled for in the current study, it predicted neither self-reported nor objectively assessed PA. The correlation coefficients between psychological correlates with PAQ-C were substantially higher than those with objective MVPA. The psychological correlates accounted for 52% of the variance of the PAQ-C score beyond that predicted by demographics and SocD, but increased explained variance by only 10% of objectively assessed MVPA. Previous studies demonstrated similar discrepancies in the contribution of determinants with adolescents' PA using two PA measures (Dishman, Darracott, & Lambert, 1992; Prochaska, Rodgers, & Sallis, 2002). The difference in level of predictiveness is likely due to self-reported error variance common to the PAQ-C and psychological correlates, but not common to accelerometry. Shared method variance may led to overestimation of the correlation (Podsakoff et al., 2012). In the current study, age was a significant predictor for PAQ-C, but not for objectively assessed PA. In a national

sample of children in grades 4 through 12, a regression analysis of correlates of PA explained more variance in PA in the oldest than the youngest groups (Sallis, Prochaska, Taylor, Hill, & Geraci, 1999). Reliability and validity of self-reports likely increase with age (Brener, Collins, Kann, Warren, & Williams, 1995).

Limitations in the present study included relationships investigated were cross-sectional in nature, which precludes casual inferences; participants were volunteers, which may have resulted in a "self-selection" bias, thereby limiting the generalization; and, although participants' age, BMI, gender, and SocD were statistically controlled in the analyses, other socio-demographics such as parental education, household income, and peer influence may be potential confounders.

Conclusion

This study was an important first step in understanding the strength of the associations between the psychological correlates and PA behavior in Chinese children. This study demonstrated the important effects of self-efficacy and autonomous motivation in predicting PA. Higher levels of self-efficacy and autonomous motivation were positively related to PA and should be included in future research. Although these prediction differed for self-reported and object PA, which is likely due to self-reported error variance common to the PAQ-C and psychological correlates but not to accelerometry, the findings of this chapter were considered helpful in order to identify predictors when assessing the subsequent intervention effect.

The following chapter documents the individual interviews which were conducted to gather information specifically about Diab, a health videogame originally developed for

American children, in which the characters are featured African-American and Hispanic children. It is still unknown whether there are difficulties in the cultural recognition and identity shift in Hong Kong Chinese children when playing and afterward. Before the intervention by using Diab, a qualitative study is necessary to collect targeted participant's perception on this intervention medium.

Chapter 5 Study 3: Phase 1 –Individual Interview on Acceptability and Applicability of an American Health Videogame with Story for Childhood Obesity Prevention among Hong Kong Chinese children

Abstract

***Objective*s:** Positive changes in psychological behavioral determinants in diet and physical activity from the use of "Escape from Diab (Diab)", a health videogame designed to lower the risk of obesity and type 2 diabetes, have been observed in research carried out in the US. However, whether the story and characters in Diab might be perceived by Hong Kong Chinese children as interesting has not been explored. This study assessed the acceptability of Diab among Hong Kong Chinese children, and explored whether the Diab story is understood by them, and whether it has potential to influence them both during the game and afterwards.

Participants and Methods: Thirty-four students (21 males, 13 females) aged 9 to 12 years were included in this study. Upon completion of all the episodes of Diab, children completed an immersion scale with 18 items, and an individual interview with 10 open ended questions.

Results: Children achieved average immersion after playing Diab with the mean score at 39.1 (SD: 9.0) higher than the median (36) of possible scores (18 to 54). Four themes emerged from the interviews including intuitive feelings about the interface, playing experience, perception of the effect of Diab on behavior change, and the applicability of Diab for Hong Kong children indicated that story immersion was a perceptible

component and the Diab developed for American children is acceptable to Hong Kong Chinese children.

Conclusions: The combination of quantitative and qualitative methods confirmed the acceptability and applicability of Diab for Hong Kong Chinese children.

Introduction

Obesity is a major health problem in developed and developing countries with many associated co-morbidities (Prentice, 2006). Childhood obesity prevalence has increased by 182% in 2-19 years old children in the US between 1971 and 2000 (Jolliffe, 2004). In 2011-2012, 31.2% and 16.9% of US children aged 2-19 years were overweight and obese (Ogden et al., 2014; Skinner & Skelton, 2014). In well-developed urban areas in China, the 2010 overweight rates for children were 32.6% for boys and 19.1% for girls (Ji, & Chen, 2013). Similarly in Hong Kong, childhood overweight increased from 11.2% in 1995 to 20.8% in 2012 (Hong Kong Department of Health, 2013).

Obesity is a metabolic disorder characterized by an increase of body fat, which results from energy imbalance with energy intake exceeding expenditure (Maziak et al., 2008). Increased consumption of fruit, vegetables and water has demonstrated positive results in weight management research (Daniels & Popkin, 2010; Rolls, Ello-Martin, & Tohill, 2004). Children aged 5-17 years old should accumulate at least 60 minutes of MVPA (WHO, 2010). However, Hong Kong youth consume insufficient servings of fruit and vegetables (Lee & Tsang, 2004; Yung, Lee, Ho, Keung, & Lee, 2010), and only 8.3% of children aged 7-12 years old in Hong Kong engaged in the recommended PA levels, suggesting that Hong Kong children may be among the most inactive children compared with their international peers (Leisure and Cultural Service Department of Hong Kong, 2012). It is imperative to discover effective strategies to modify children's dietary and PA behaviors.

Videogames can be effective at capturing players' minds and generating positive emotions by immersing players in the game (de Gortari, Aronsson, & Griffiths, 2011).

Video games increase enjoyment and fun through their interaction by characters and instant feedback. Serious videogames targeted at achieving health enhancement called "Game for Health (G4H)", are designed to persuade players to modify their health-related attitudes or behaviors through playing and entertainment (Thompson et al., 2008). G4H have been considered an innovative channel and a fantasy trigger to motivate health behaviors (Baranowski et al., 2008). Growing interest in video game-based interventions have resulted from some G4H increasing children's PA (Biddiss & Irwin, 2010), and dietary behaviors (Baranowski, Baranowski, Cullen, Marsh, Islam, Zakeri, & Honess-Morreale, 2003). However, there has been a lack of video game-based obesity prevention research among Hong Kong primary school children.

"Immersion" is a phenomenological experience of people's engagement with narratives, a process in which people travel into the story world and are changed by the journey (Green & Brock, 2000). Story or narrative immersion can influence a player's cognition, affect, attitude and, potentially, health behavior (Gerrig, 1993). Story immersion is an attraction of games for players and has been hypothesized to be an important attribute that links video game interactivity with enjoyment. Well-crafted narratives embedded within a G4H may be especially suitable for health behavior change, as players may experience psychological immersion whilst fully engaged in games and thereby pay close attention to embedded messages and more closely follow behavior change procedures. "Escape from Diab" (hereinafter called Diab) is a G4H with story immersion designed to lower the risk of obesity and type 2 diabetes by changing children's diet and PA behaviors. Positive changes in psychological and behavioral indicators (i,e., fruit and vegetable preference, fruit and vegetable self-efficacy, and PA

self-efficacy) were detected using Diab in research in the US (Lu, Thompson, et al., 2012). However, given obvious cultural difference, it is not clear how Hong Kong Chinese children will perceive Diab. Therefore, this study assessed the acceptability of Diab, and whether it might influence Hong Kong Chinese children's diet and PA behaviors both during and after playing it.

Methods

Game for Health "Diab"

Diab is a G4H within a three-dimensional setting. The G4H has nine episodes which tell the story of Deejay, an athletic, healthy modern-day youth who accidently falls through the floor of an abandoned building and a time/location warp. Deejay awakens to find himself in the dark and dreary land of Diab governed by the evil King Etes. In this land, fruit, vegetables, and PA are forbidden to make the population lose fit and thereby more malleable. Upon his arrival, Deejay was captured by the King's guard. After Diab, Deejay should find several friends and together plot to escape. To enhance personal fitness with which to escape King Etes and his guards, DeeJay guides his new friends to eat healthier (more fruit, vegetables and water) and to engage in more PA. Main characters are shown in *Figure* 5.1. The players perform behavior change activities as part of playing the game. There are alternative game endings (saving the king or not) which are dependent on the player's personal decisions related to the behavior change choices throughout the game. After completion of each episode, children are able to replay the inserted minigames but cannot replay the goal setting aspect. The children are encouraged to play the next episode during the next scheduled playtime. An outline of

each session is presented in table 5.1.

Table 5.1. A session by session outline of the Diab components

Episode	Components	Description
1	What is a vegetable?	Find all the healthy vegetables before DeeJay's energy runs out
	Find the safe house	Help Deejay find his new friends and answer their questions on fruit, vegetables, and water intake
	Etes Battle	Battle game to gain 3000 points
	Snack balance	Show DeeJay's friends how to create a balanced snack from food in the safe house
2	Cross the street	Answer the questions on fruit, vegetables, and water intake
	Push DeeJay	Send Deejay to the safe house
	Breakfast balance	Help Dagan eat a balanced breakfast
3	Fruit turn plate	Choose the fruit from turn plate
	Dagan's soccer practice	Play football with three balls
	Lunch balance	Help Dagan eat a balanced lunch
	Help your neighbor	Run with a little boy to find the right place
4	Vegetable turn plate	Choose the vegetable from turn plate
	Sneak by the guards	Escape from the unsafe room
	Dinner balance	Help Bearspaw make a better dinner
	Mayza draws pictures	Draw pictures and try not to be caught by guards
5	Home exercise	Find convenient facilities/equipment at home to do exercise
	Your sedentary time	Answer questions on your daily sedentary time.
	Exercise promotion	Do some exercise to balance your meal
6	Rope skipping	Rope skipping competition
	Aerobic activities list	Choose aerobic and non-aerobic activities
	Soccer Pong	Football game
	Find Delinda's cell	Follow the robots through the doors, but don't bump into them
7	What is fruit?	Choose fruit for supplementary energy
	Strength activities list	Choose strength and non-strength activities
	Top o's the train	Run and get points on the train
	Bearspaw's challenge	Push-up competition with Dagan
8	Activity groups	Activate at least 6 activities
	Deejay of the shadows	Walking under the shadows of buildings
	Last bridge	Run to avoid being crushed by stones
9	Last hurrah	Run to escape from the evil king

The design of Diab was predicted on the integration of the social cognitive (Bandura, 1986), self-determination (Ryan & Deci, 2000), and persuasion (Thompson et al., 2008) theories. Diab integrated: (1) knowledge games about diet and PA (i.e., "what is a vegetable?" "How to make balanced snack and balanced meal for breakfast, lunch and dinner?" "Which are aerobic and non-aerobic activities?"); (2) goal setting activities (after each episode, setting personalized goals on subsequent behavior changes tailored to their current status with multiple steps, consisting of selecting value and reason statements, goals and days, summary display of goal and reasons, behavior inoculation, and anticipatory problem solving including solution selection); and (3) motivational statements to inspire children's behavior modification towards goal-related lifestyle change.

Figure 5.1. Main characters from "Escape from Diab"

Research design

Quantitative and qualitative methods (survey and individual interviews) were used to assess Chinese children's perception of the storyline and the content delivered by Diab. Upon completion of the nine episodes, children were required to complete a 18-item immersion scale, adapted from the narrative transportation scale (Green & Brock, 2000), which demonstrated good internal consistency (α = .89). Participants rated their levels of agreement with statements (e.g., "I can easily imagine the things that happened in "Diab", "At least one of the Diab characters reminds me of myself") on a 3-point Likert scale (1 = do not agree; 2 = somewhat agree; 3 = agree a lot). The score was summed after recoding the reversed items. Possible scores ranged from 18 to 54.

Individual interviews were then conducted to assess participants' attitudes about playing the G4H. Four independent dimensions (amount, content, form, and mechanism) should be considered when studying the effects of video game playing (Gentile & Stone, 2005). Amount refers to the amount of time spent playing the game. Content focuses on the message, topic and story of the video game. Form is the type of activity performed in the game. Mechanism is the methods of interface with the game. Based on these dimensions, the research team developed an interview protocol using commonly accepted methods (Locander, Sudman, & Bradburn, 1976) comprising 10 open ended questions with follow-up prompts and probes (Table 5.2). The individual semi-structured interviews were conducted in person either by the primary author or a trained research assistant (S.C.K) upon completion of all episodes of Diab in the computer rooms of the participating school. The interviews were audiotaped and lasted approximately 10 to 15 minutes.

Table 5.2. Interview questions

1.	How long did you spend playing each episode? Was there anything about playing 'Diab' that made you uncomfortable? If yes, what made you feel uncomfortable?
2.	Did you have difficulty with the English language of the video game? What percent of English could you understand?
3.	What did you think of the characters in the video game?
4.	Please tell me how much you liked the game. If the possible score was from 0 (did not like at all) to 10 (liked a lot), what score would you give this video game? • Please tell me what you liked about the video game. • Please tell me what you did not like about the video game.
5.	Please tell me how difficult you thought the game was. If the possible score was from 0 (very easy) to 10 (very difficult), what score would you give for difficulty level of the game? • Please tell me which episode was the easiest. • Please tell me which episode was the most difficult.
6.	What diet and PA goals did you set while playing the game? • Did you meet the goals you set when playing? • Please tell me why you did or did not meet the goals?
7.	Did you learn about fruit, vegetables, water and PA? Did what you learned help you make healthier changes in your diet and PA behaviors?
8.	What do you think about the dietary and PA behaviors in Hong Kong Children? Were the environments in "Diab" similar to those in Hong Kong, including foods and exercise habits in the game?
9.	Do you think "Diab" is suitable for Hong Kong children? Would you recommend the video game to your friends?
10.	Is there anything else you want to tell me about the game that we did not talk about?

Note: Diab, "Escape from Diab".

Participants

Participants were recruited from four primary schools in two Hong Kong districts,

with varied student social economic backgrounds. A total of 34 students (21 males, 13 females) from grades 4 to 6, aged from 9 to 12 years (9 years, n = 4; 10 years, n = 8; 11 years, n = 21; 12 years, n = 1), returned written informed consent and were included in this study. All participants received prior medical clearance to ensure there were no physical, psychological, sensory, or genetic limitations. Complying with standard anthropometric methods (Cameron, 1978), the children's height and weight were measured before the study with a FISCO measuring tape (CMS Weighting Equipment Ltd, London, UK) and a Tanita electronic digital scale (Model No. HD305, Tanita Inc, Tokyo, Japan). Height was measured to the nearest 0.1cm and weight was measured to the nearest 0.1kg. Body mass index (BMI, kg/m^2) was calculated as weight divided by height squared. The BMI of the participating children ranged from 14.11 to 29.31 kg/m^2 with a mean value of 18.87 kg/m^2. The study was approved by the Hong Kong Baptist University Committee on the use of Human and Animal Subjects in Teaching and Research.

Data analyses

Cronbach's alpha of internal consistency was calculated on the 18-item immersion scale. Means and SD were calculated to describe the distribution of immersion scores. All interviews were transcribed verbatim and checked carefully for accuracy with reference to the original audiotapes. A framework approach, a widely used and well developed method for analyzing qualitative data (Pope, Ziebland, & Mays, 2000), was used for analyzing the individual interviews. Framework analysis, developed by Ritchie and Spencer (1994), provides distinct, but highly interconnected, stages of systematic and transparent data analysis, enabling researchers to work through and understand qualitative

data (Malterud, 2001). Framework analysis suits research with pre-designed samples, specific topics, a limited time frame, and a priori issues. The five key stages of this technique are summarized in Table 5.3.

Table 5.3. The five stages of framework analysis

1. Familiarization	Sorting audio and written data, sifting through the transcripts
2. Theme identification	Searching for patterns and similar words, identifying key issues
3. Indexing	Extracting specific comments and forming a thematic framework applicable to the data
4. Charting	Rearranging the data and lifting the data from original context according to the extracted thematic reference
5. Mapping and interpretation	Synthesizing the content of each theme, reviewing research notes, comparing perceptions, accounts and experiences for different patterns, and explaining the meaning

Results

All 34 children completed the task and 32 provided complete immersion questionnaire data (α = .91). The immersion score ranged widely from 20 to 51 and was normal distributed (p = .20 for Kolmogorov-Smirnov test). The mean score was 39.1 (SD: 9.0), which was higher than the median (36) of possible scores (18 to 54). Skewness (-0.076) and Kurtosis (-0.576) were lower than the absolute value of 1.0. Children achieved a median amount of immersion in Diab.

Four themes emerged from interview data, including: intuitive feelings about the interface, playing experience, perception of the effect of Diab on behavior change, and

the applicability of Diab for Hong Kong children.

Intuitive feelings about the interface

Children spent from 25 to 60 minutes on each episode. While, 30 children reported nothing made them uncomfortable during playing Diab, 3 children reported slightly uncomfortable feelings (see these comments below).

"Actually, I felt a bit dizzy when I was playing the game. But this feeling did not exist in all the episodes, just one or two sessions. I think it may be related to the 3-D image. I may not be used to screen". (10 year old boy)

"*Sometimes, my ears hurt after playing. It was due to the tight earphone. The sounds were a bit terrible if failed to complete the task". (11 year old boy)*

"I was tired when I was playing the difficult episode, such as the second one. Um, I am a girl and I needed to spend more time on these episodes. The long time staring at the screen made my eyes tired". (10 year old girl)

Due to varying levels of English proficiency, how much of the language participants could understand ranged from 20% to 90%. Twenty two children (64.7%) reported they could understand 70% or more of the content. Eight children (23.5%) could understand 40-70%; and four children (11.8%) could only understand 20-40%.

"I am a 4th-grade student. I don't know some of the vocabulary about fruit and vegetables. Well, the pictures beside could give me some remind and I may guess what they are. So even I only understood 50% of language, I don't think it is a barrier for me to play the game". (9 year old girl)

"I am so shy to say that I could not understand the English well even I am Grade 6 now. I had the bad performance in English test. The translation of food and PA

vocabulary provided by the teacher helped me a lot on the comprehension". (11 year old boy)

The character design in the video game was generally considered vivid and fun. Participants generally considered it easy to distinguish the good and the bad characters. For example, the antagonists (the King and his guards) were crafty and evil, and due to their unhealthy lifestyles, both the king and guards were overweight and obese, which meant that their actions were clumsy. Deejay and his friends were resourceful, brave, full of team spirit and had healthy body shapes.

"*These young people are very smart and healthy. They would like to try to solve the problems. The good and bad persons are similar to the real world, But…I just think the girl in purple clothes (named "Mayze") had little hair and designer should give her more hair to make her beautiful". (10 year old girl)*

"Um…I don't like the appearance they look. They are ugly. But to be sure, I quite like their characters". (11 year old girl)

Diab playing experiences

Table 5.4 presents the distributions of the scores of all the children and by genders, for how difficult they considered Diab (0, very easy; 10, very difficult), and how much they liked it (0, not like at all; 10, very like). More than half the children (19 of 34) considered Diab to have moderate difficulty with scores ranging from four to six. Comments on difficulty indicated both playability and challenge in Diab. Ten children scored it seven or higher for difficulty. Five children scored it three or lower. The first episode (involving picking up the fruit and vegetables while crossing the road) was considered the easiest section. The most difficult episodes were reported to be those

involving escaping while being chased by the King and making balanced snacks, breakfasts, lunches and dinners.

"*You know, I can accept the game well because it was neither too easy to lose my interest nor too difficult to dampen my initiative. I spent too much time on making balance on the dinner. If any diet component was too much or too little, the plan could not be passed. But this method helped me learn a lot on how to balance my own meal". (10 year old boy)*

The overwhelming majority of children (29 out of 34) stated that they liked the game with a score equal to or greater than seven. The game was considered fun, challenging, and enjoyable. However, issues surrounding playing stations and game controllers made them wait too long to restart the game when there were issues with the game freezing.

"I liked the game very much. But, I think, the background music was a bit boring". (11 year old girl)

"Um, the game controller did not work sometimes". (11 year old girl)

Table 5.4. The distribution of scores children marked for Diab

	1	2	3	4	5	6	7	8	9	10
How difficult did you think the game was? (0, very easy; 10, very difficult)										
Male	3	1		1	8	2	4	1		1
Female			1	1	4	3	3	1		
Total	3	1	1	2	12	5	7	2		1
How much did you like the game? (0, not like at all; 10, very like)										
Male			1		1		5	8	4	2
Female					2	1	4	3	2	1
Total			1		3	1	9	11	6	3

Participants' perception about the effect of Diab on behavior change

Goal-setting followed the end of each episode and was integrated into the game to help children change their own lifestyles. However, only 15 students set goals for each episode and six students set part-goals. The remaining participants did not engage in the goal setting seriously as they wanted to complete the episode as quickly as possible. Due to the limited time arranged for playing after school, some children had no time to set goals.

"I have set the goals for each episode. I think I meet the goals with the help of my parents". (11 year old girl)

"I did not conduct goal setting carefully since I want to pass the episode quickly. Also, I do not think it is necessary to set the goals each episode because my dietary and PA habits are healthy now". (11 year old girl)

All children agreed that Diab was an appropriate, innovative and helpful way to deliver knowledge about fruit, vegetables and water intake and PA engagement. The information they received could potentially motivate them to modify their health behaviors, although four participants expressed their uncertainty as to the long-term effects of Diab on behavioral modification.

"Definitely, I got much new knowledge from the game. If I am taught the knowledge through the lecture, I may forget them soon. But this time, I learn them through play and practice. All are impressive and helpful for my daily life". (9 year old girl)

"Um, to be sure, after playing the Diab I have learnt the knowledge which I didn't know before. During these days, I remembered to change my behaviors and try to intake more fruit and water. But I have no idea if the change could be lasted too long

without the motivation from game". (11 year old girl)

"I just think the video has more effects on dietary than that on PA, because the real PA activities are better than PA education from the video". (12 year old boy)

Applicability of Diab for Hong Kong children

Of the 34 participants, 20 children indicated that the game was similar to Hong Kong in terms of the availability of snacks, distribution of stores, and the physique of Hong Kong people. Several children expressed that there were environmental differences between the game and Hong Kong with regards to the buildings and streets. Students pointed out the high-density situation in Hong Kong, and the lack of outdoor play space which may limit children's activity. The majority of children agreed that Hong Kong people eat more high-calorie foods and often have meals in fast food restaurants due to a rapid pace of life. The children also agreed that vegetable intake was insufficient among Hong Kong people. Meanwhile, Hong Kong people are more likely to be inactive because of intense work and study pressure. Nearly all the children agreed that the game was suitable for Hong Kong children and they would recommend Diab to their friends. Despite the fact that there were some difficulties in the comprehension of Diab due to the varying English proficiency, language was not considered a barrier which would affect the dissemination of knowledge and health behavior modification.

"There are many stores and restaurants in the game. This is quite similar with traditional areas in Hong Kong, such as Mong Kok, Causeway Bay, etc". (11 year old boy)

"I cannot see Hong Kong people do the PA in the street because the streets here are very crowded". (10 year old boy)

"Yeah, I believe the game help me a lot on how to choose foods and to engage in more PA. And I highly recommend the video to my classmates. I will continue to play the mini games offered in Diab at home". (9 year old boy)

Discussion

As the childhood obesity crisis continues, interventions are needed that can effectively tackle this epidemic. Video games are a popular form of entertainment and integrated into the fabric of children's lives. G4H in Western countries have influenced psychological mediators or moderators of PA and dietary outcomes (Guy, Ratzki-Leewing, & Gwadry-Sridhar, 2011). This study is the first to report the acceptability of a G4H with story immersion among Chinese children, and thereby provides an important contribution to G4H interventions for childhood obesity.

Diab was perceived to be an immersive game by this sample of Hong Kong Chinese children. The average score they achieved (mean (SD): 39.1 (9.0)) was similar to the prior study of Diab in the US children (mean (SD): 40.8 (8.2)) (Lu, Thompson, et al., 2012). Four themes emerged from the qualitative interviews: intuitive feelings about the interface, playing experience, perception of the effect of Diab on behavior change, and the applicability of Diab for Hong Kong children. With respect to the interface, the majority of 34 children reported that they were comfortable with the game. The character design was generally considered vivid and fun, and the language was not reported to be a major barrier for this Hong Kong Chinese sample. Most reported that they enjoyed playing Diab and also enjoyed the emphasis on healthy eating and PA. Diab was considered to be moderately difficult in both playability and challenge. The majority of

children reported that Diab motivated them to change some diet and PA behaviors. Their perception of the environmental background of the game compared to Hong Kong was that the two were similar, as were the lifestyles of the antagonists compared to Hong Kong children. Most participants agreed that Diab was suitable for Hong Kong Chinese children and would recommend the game to their friends. All these findings suggest that, Diab, a G4H with story immersion is acceptable and applicable among Hong Kong children.

According to social cognitive theory, goals are set for behavior change and can stimulate and increase an individual's' cognitive abilities, as well as their reactions to outcomes (Bandura, 1991). Goal setting, as a key component of self-regulatory processing, focuses on the effort behind behavior change. The concept of goal setting has been employed for reducing drug abuse (Cheung & Ngai, 2013) and tobacco use (Ziedonis et al., 2012) among Hong Kong youth, however, it has not been applied to childhood obesity prevention. Within Diab, goal setting is integrated as a multistep process at the end of each episode (episode 1 to 4: diet goals; episode 5 to 8: physical activity goals). Implementation intentions (i.e., specific foods, number of days to attempt goals) and coping intentions (i.e., most likely barrier to achieving the goal and the most likely effective solution for overcoming the barrier) are two phases of the goal setting process (Gollwitzer, 1999). The players are asked to develop an implementation plan (e.g., eat one more portion of fruit for your after-school snack in the following 4 days) and a plan to overcome potential barriers (e.g., fruit or juice is not always available at home) to the achievement of their goals (e.g., ask your parent to have more available at home). The prior study of Diab identified that the most important diet-related values and

reasons in US children were getting good grades and being healthy; PA-related important values and reasons were having energy to do homework and not missing school (Simons et al., 2013). However, the potential of Gollwitzer's (1999) approach to bridge the intention-behavior gap was limited in this study by the fact that that only half of participants completed the goal setting session seriously. The remaining children only partly completed it, or skipped the component entirely, as they were eager to pass the episodes as quickly as possible due to limited time. The diet- and PA-related values, goal selections, reasons, and barriers in Hong Kong children were not adequately explored. To maximize the behavior change potential of Diab, researchers should pay more attention to completing the goal-setting in future studies.

Conclusion

Even though this study did not use a large sample, the combination of quantitative and qualitative methods has provided rich information which has confirmed the applicability of a G4H with story immersion for Hong Kong Chinese children. Diab, a multimedia program with inserted video game and behavior change procedures, and a story links the pieces, aims to motivate players to reduce unhealthy obesity-related behaviors, and it appears that the videogame developed for American children is acceptable to Hong Kong Chinese children. In addition, story immersion was a perceptible component. However, this research was not an outcome study. Therefore, further studies are warranted to explore and quantify the effects of the game on Hong Kong children's behaviors and adiposity. As a result, the following chapter describes the

implementation and evaluation of a pilot intervention study designed to examine the effect of playing Diab on the obesity-related outcomes in Hong Kong Chinese children.

Chapter 6 Study 3: Phase 2 - The Intervention Effect of a Health Videogame with Story Immersion for Childhood Obesity Prevention among Hong Kong Chinese Children

Abstract

Objectives: Diab, is a health videogame designed to lower the risk of obesity and type 2 diabetes through behavior change components that were integrated into activities within the game storyline. Story immersion refers to the experience of being fully absorbed within a story and is a key factor that contributes to the mechanism of behavior change. This study evaluated the effect of playing Diab on children's health outcomes. Additionally, the study sought to explore whether children with high immersion levels would have greater positive health outcomes and whether the treatment effect differed between non-overweight and overweight children.

Methods: A two-group, non-randomized design with three data collection points (baseline, immediately postgame (post 1), 8-10 weeks postgame (post 2) was used. One hundred and seventy-nine children aged 8~12 years (mean = 10.2 years; 103 males, 76 females) were recruited from 4 schools from two districts in Hong Kong. Participants in the treatment group played Diab. Children's motivation, self-efficacy, preference for fruit, vegetables, water and PA, and PA behaviors were measured. Participants in the treatment group were divided into high and low immersion subgroups according to whether their immersion scores were above or below the median of possible immersion scores.

Results: A mixed-model repeated measures analyses of covariance showed that no significant treatment effects were found for all measures across time between the

treatment group and the control group. At post 1, significant increases were observed in self-efficacy for PA (p = .031), PA preference (p = .009) and self-reported PA (p = .019) in the treatment group, while significant reductions were observed in intrinsic motivation for fruit (p = .018) and vegetables (p = .011) in the control group by using paired t-tests. However, improvements were not sustained at post 2. Compared to the low immersion group, children with high immersion level had increased intrinsic motivation for fruit (p = .027) and water (p = .004), autonomous (p = .047) and controlled motivation (p = .036) for PA at post 1, but these did not demonstrate significance at post 2. Similarly, the overall treatment effects were not detected across time between the high and low immersion groups. No significant differences were found between non-overweight and overweight children for all measures at both post 1 and post 2.

Conclusion: This study conducted with Hong Kong Chinese children found that Diab partially motivated children to improve their motivation, self-efficacy and preference for dietary and PA behaviors immediately after completing the game. However, the effects were not sustained 8-10 weeks later. Health videogames, such as Diab, with appealing characters and immersive storylines have the potential to provide innovative mediums for children's behavior change, however their lasting effectiveness and mechanisms of change require to be investigated more thoroughly.

Introduction

With the recent increases in prevalence, childhood obesity has now become a worldwide public health crisis. Obesity is a multisystem disease, which causes hypertension, hyperinsulinaemia, dyslipidaemia, endothelial dysfunction, chronic inflammation (Ebbeling, Pawlak, & Ludwig, 2002) and increases the risk of type 2 diabetes and various cancers (Mokdad et al., 2003). Obesity tracks from childhood into adulthood (Freedman et al., 2002) which shortens the lifespan, impairs functional ability and diminishes quality of life (Danaei et al., 2009). Effective methods encouraging children to adopt healthy diets and participate in sufficient PA are required.

Efforts aimed at obesity prevention may benefit from innovative technologies that provide an alternative method to encourage healthy behaviors. Recently, there has been a growing interest in video games, not only as an entertainment, but also as a means to educate and teach (Durkin, 2010). In the literature, we can see growing numbers of video games used for serious purposes, called "serious games". Serious games are featured both with "fun-ness" (i.e. the components entertain plyers through animation, storyline, sound effects, and so on) and "serious-ness" (i.e., the components promote behavior modification through tailoring, problem solving, goal setting, and so on). "Games for Health" (G4H), one particular type of serious game, have been designed to encourage players to modify attitudes and behaviors to health through playing and entertainment (Thompson et al., 2008).

Diab is a G4H designed with story immersion and entertainment and behavior change components have been integrated into activities within the storyline. The design of Diab was based on social cognitive (Bandura, 1986), self-determination (Ryan & Deci,

2000) and persuasion (Thompson et al., 2008) theories. Additionally, tailoring, knowledge mini-games, goal setting, problem solving, motivational statements, goal review, feedback, and behavioral inoculation were integrated into Diab (Thompson et al., 2008). SDT proposes that more self-determined forms of motivation lead to optimal functioning and well-being. SCT posits that behavior change is a function of self-efficacy (i.e. the confidence to adopt specific behaviors). As a G4H, Diab aims to lower the risk of obesity and type 2 diabetes by focusing attention on diet and PA and in turn changing attitudes and behaviors. Playing Diab has led to an increase in fruit and vegetable consumption by about 0.67 servings per day in American children aged 10-12 years (Baranowski, Baranowski, Thompson, Buday, et al., 2011). However, the effect of health videogames on childhood obesity prevention is understudied.

A narrative is defined as "*the framework for the sequence of events that make up the plot we see, and the story we imagine*" (Bizzochi, 2007, p.2). The narrative is the basic feature and universally enjoyed aspect of playing (Fisher, 1985). Narrative or story immersion refers to the experience of being absorbed in the story and immersion is an active engagement with the dynamic narrative process. The immersion provided by the story world in videogames can explained as a state of mental absorption, where the player is consumed by the story (Schneider, 2013). Health videogames are interactive and capture player's minds, influencing cognitions and affect, generating positive emotions by immersing players, and potentially, causing effects on health behaviors (de Gortari et al., 2011). High story immersion is proposed to engender a greater response to the health outcome (Bowman & McMahan, 2007).

In the study one on the literature review of video games-based intervention studies, one third of the studies recruited child participants based on their weight/body composition status. Overweight and/or obese children were included exclusively to receive the treatments. Overweight children were 4.5 times and 2.4 times more likely than non-overweight children to have elevated systolic and diastolic blood pressure, respectively (Freedman, Dietz, Srinivasan, & Berenson, 1999). These children are more likely to have an increased risk for various chronic diseases later in life (e,g. hyperlipidemia, hyperinsulinaemia, hypertension, and type 2 diabetes) (Freedman, Khan, Dietz, Srinivasan, & Berenson, 2001). Theoretically, high-risk individuals may be more motivated to become involved in prevention programs, and overweight children are more likely to benefit from the treatment than their non-overweight peers.

Thus, the current intervention study tested the following hypotheses:

(1) Playing Diab would improve children's self-efficacy, motivation and preferences for diet and PA and subsequent health behaviors.

(2) The high story immersion in children's response to exposure to Diab would engender a more beneficial effect.

(3) As a high-risk group, overweight children would be more motivated in the intervention and therefore more likely to benefit from the treatment than their healthy weight peers.

Methods

Design

The current trial was a two-arm, non-randomized controlled design. Outcome assessments were conducted at baseline; immediately postgame (post 1); and 8-10 weeks postgame (post 2: this duration was the same as the intervention duration for each individual school). Written informed consent was obtained from each participant and their parents. The study was approved by the Hong Kong Baptist University Committee on the use of Human and Animal Subjects in Teaching and Research and was registered with Centre for Clinical Research and Biostatistics (CCRB) in the Chinese University of Hong Kong (Identifier: CUHK_CCT00434).

Participants

Participants were recruited from four primary schools from two Hong Kong districts. These schools used English medium instruction (EMI), which meant that children had acceptable levels of English language comprehension (which is the language used in the Diab). All four schools had a similar teaching methods, quality and similar environments which minimized any potential moderating effects of socio-economic status on intervention effects.

Students with any contraindications or physical diseases (heart, lung, liver, kidney, other vital organs, endocrine diseases, drug side effects and so on) and psychological illnesses that may prevent them from participating in PA and eating a normal diet were excluded. The four schools provided samples of 23, 83, 41 and 32 students, respectively. A total of 179 students aged 8~12 years (mean = 10.2 years; 103 males, 76 females) were included in the study. Setting a significance level of $p < .05$, power of 80%, a constant

correlation of 0.3 for 3 repeated measures, and taking 20% drop out rate into account a total sample size of 176 (two groups, n = 88 each group) was required to detect a small-to-moderate overall effect (Cohen's d = .25), which was also estimated from similar studies (Baranowski, Baranowski, Thompson, Buday, et al., 2011; Maddison et al., 2011).

Intervention

Game for Health: "Diab"

Diab uses three dimensional sets and animated characters to tell the story of DeeJay, an athletic and healthy, modern-day youth who falls through the floor of an abandoned building where fruit, vegetables, and PA are forbidden by the evil King Etes. DeeJay is befriended by a group of youth and they begin to plot their escape from Diab by adopting a healthier lifestyle. The video game comprises nine episodes, within each episode there are three to four action-adventure levels. Children were required to set goals at the end of each episode (diet goals in episodes 1 to 4 and physical activity goals in episodes 5 to 8). Goal setting in the game included action goals (i.e., specific foods, number of days to attempt goals) and coping goals (i.e., the most likely barrier to achieving the goal and an effective solution for overcoming the barrier). Active behavior change procedures are integrated into each level.

Procedure

Based on the schedules of all the schools, the intervention was arranged during morning sessions before classes or afternoon sessions after school. One or two sessions were offered each week and each session lasted 40 to 90 minutes. Based on the different arrangements of participating schools, the intervention lasted between 8 and 10 weeks. Two schools had one play sessions (1.5 hours per session) after school each week and the

other two had two sessions before classes (40 minute per session) each week. Participants who had schedule conflicts with play sessions were assigned to the control group. The remaining participants were randomly assigned to either the treatment or control groups. Prior to the study, Diab was installed in the multi-media classroom computers and tested. Each participant in the treatment group conducted the game sessions on an individual computer in the school's multi-media classroom. During each session, children were asked to play one episode. If the student had time remaining in the session, the player could return to the current or previous episode and replay the mini-games. However, players could not move on to the following episode until the next game session. A translation of food and PA vocabulary were provided on the multimedia screen during play. During the session, one to two researchers were present to monitor children's progress and to solve minor hardware or software problems. Children in the control group received no intervention during the program. After the final testing was complete, a Diab game CD and a game controller were delivered to participants in the control group to encourage them to play Diab at home.

Demographics

Participant's sex, age, school, and school banding were recorded. As described in Chatper5 methods section (page 103), children's height and weight were measured according to the standard anthropometric methods and BMI was calculated. According to the international BMI cutoff points for childhood overweight and obesity (Cole et al., 2000), participants were classified into non-overweight and overweight groups.

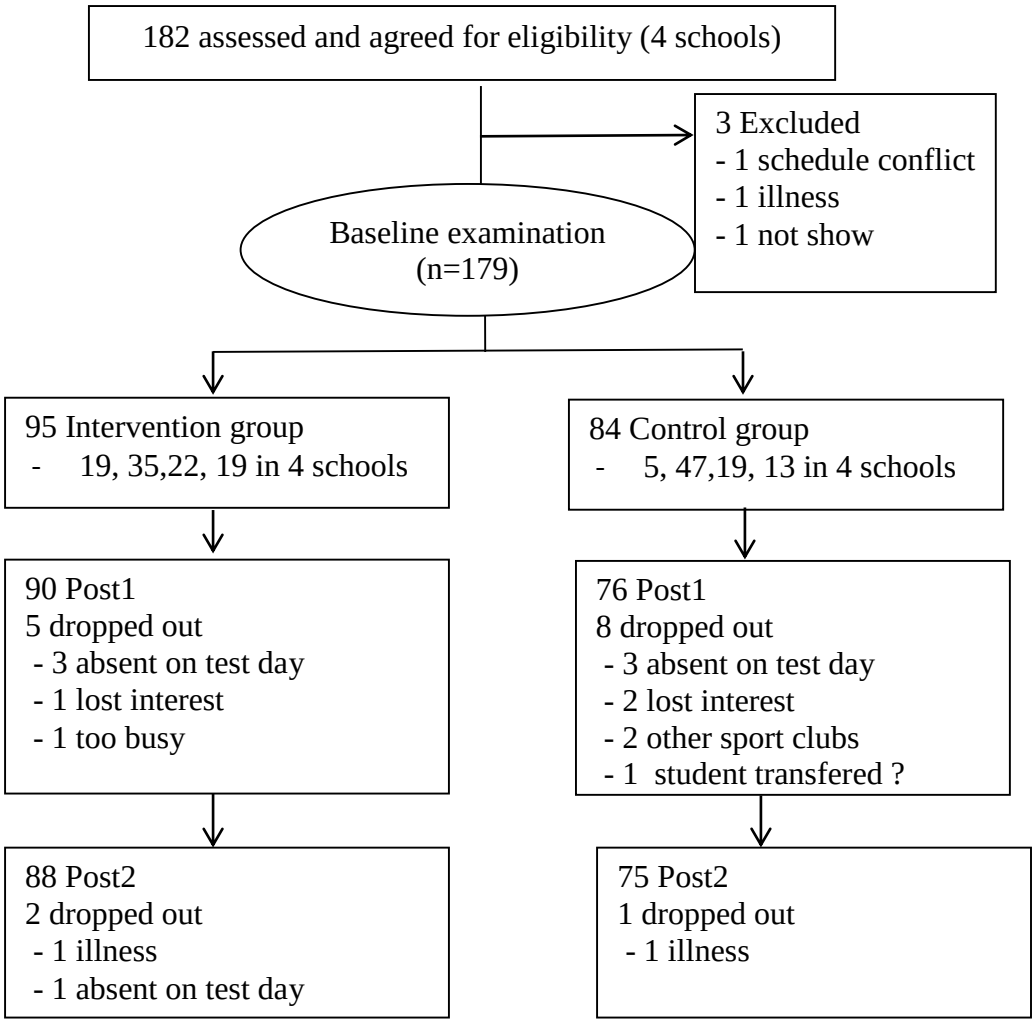

Figure 6.1. A CONSORT statement of participants flow

Measures

Immersion

Immersion was assessed immediately after the children had completed all episodes of Diab using an 18-item immersion scale. This scale is described in detail in the Chapter 5 method section (page 103). The maximum possible score was 54, and the minimum possible score was 18.

Social desirability

Social desirability (SocD) reflects the desire to give answers that are socially desirable or expected and has been observed in children and may distort responses (Dadds et al., 1998). To control the effect of social desirability, the 9-item "Lie Scale" from the revised children's manifest anxiety scale (Reynolds & Paget, 1983) was used. The detail is presented in the Chapter 4 method section (page 85).

Health outcomes

1. Intrinsic motivation for fruit was assessed using a 12-item scale (α = .73) (Lu, Thompson, et al., 2012). Children indicated reasons as to why they eat fruit on a 4-point Likert scale, for example, "I usually eat fruit because it is important to me to eat fruit; because I enjoy eating fruit" (1= I am not sure; 2 = I am a little bit sure; 3 = I am very sure).

2. Intrinsic motivation for vegetables was measured using a 9-item scale (α = .72) (Lu, Thompson, et al., 2012). For example, "A reason I usually eat vegetables is because it is fun to eat vegetables; because it is important for me to eat vegetables" (1= I am not sure; 2 = I am a little bit sure; 3 = I am very sure).

3. Intrinsic motivation for water was assessed using a 9-item scale (α = .73) (Lu, Thompson, et al., 2012). Sample item included "A reason I usually drink water is because drinking water is good for my health; because drinking water makes me happy" (1= I am not sure; 2 = I am a little bit sure; 3 = I am very sure).

4. PA motivation was assessed with a validated 16-item scale (Deci & Ryan, 2010), which contains three items for intrinsic motivation (α = .84), five items for identified regulation (α = .81), three items for introjected regulation (α = .71), and five items for external regulation (α = .72). A score for autonomous motivation was created by

summing the items in the intrinsic motivation and identified regulation subscales, whereas the items under introjected and external regulations were summed to form a controlled motivation score. The detail of the motivation scale is described in the Chapter 4 method section (page 84).

5. Fruit self-efficacy was assessed using a validated 12-item scale (α = .86) (Baranowski et al., 2010). Each item (e.g. "How sure are you that you can …?") asks about fruit intake behavior (1= I am not sure; 2 = I am a little bit sure; 3 = I am very sure) such as, "eat 1 portion of fruit at lunch at least one time on a school day" and "eat 1 portion of fruit for a snack at home on at least four days a week".

6. Vegetable self-efficacy was assessed using a 8-item scale (α = .85) (Baranowski et al., 2010). Each item (e.g. "How sure are you that you can …?") asks about vegetable intake behavior (1= I am not sure; 2 = I am a little bit sure; 3 = I am very sure) such as, "eat 1 portion of a vegetable at lunch at least one time on a school day" and "each 1 portion of vegetables for lunch for most non-school days, including weekends".

7. Water self-efficacy was assessed using a 5-item scale (α = .79) (Baranowski et al., 2010). Each item (e.g. "How sure are you that you can …?") asks about water intake behavior (1= I am not sure; 2 = I am a little bit sure; 3 = I am very sure) such as, "drink only water whenever you are thirsty at least one day" and "drink 6 glasses or bottles of water for at least 4 days a week".

8. Fruit, vegetables and water (FVW) preferences were measured using a validated 37-item scale (α = .90) (Domel et al., 1993). Items ask how much children like different foods (e.g., plums, oranges, water, etc.) using a 4-point Likert scale (1 = I have never tasted it; 2 = I do not like it; 3 = I like it a little; and 4 = I like it a lot).

9. PA preference was assessed using a validated 28-item scale (α = .84) (Sallis et al., 1996b). In a similar way to the FVW preference scale, each item asks about varieties of PA (e.g., bicycling, swimming, dancing, etc.) A detailed description of this scale is presented in the Chapter 4 method section (page 83).

10. Physical activity self-efficacy was assessed using a 12-item scale (α = .91) (Jago et al., 2009). Example items included "how sure are you that you have the ability to do physical activates like running, dancing, bicycling, or jumping rope really well" "How sure are you that you can be physically active more than 30 minutes for one day, even when you have lots of other things to do" (1= I am not sure; 2 = I am a little bit sure; 3 = I am very sure). A detailed description is presented in the method section of Chapter 4 (page 83).

11. Self-reported PA was assessed using the PAQ-C (α = .79) (Kowalski et al., 1997). A detailed description of this scale is presented in Chapter 3 (page 55-74).

12. Objective PA was measured using ActiGraph GT3X (ActiGraph, Pensacola, USA) at baseline and at post 1. Due to school time crash, objective PA was not assessed at post 2. The methods for measuring and preparation of the accelerometer data are the same as indicated in the method section of Chapter 3 (page 61). Cut-off points developed by Evenson et al. (2008) were used to determine the intensity of PA (Sedentary $\leq$ 100 counts per min; LPA > 100 counts per min; MVPA $\geqslant$ 2296 counts per min). Of the 179 participants, 82.1% provided $\geqslant$ 3 valid days of accelerometer data at baseline and 60.3% at post 1. The children who provided both valid accelerometer data at baseline and post 1 were included for the final analysis of objective PA, among which, 80.5% had $\geqslant$ 1 valid

weekend day. Little's chi-square ($\chi^2_{(10)} = 69.40$, $p = .354$) indicated that accelerometer data were missing at random at post 1.

Statistical analyses

For each scale, items were summed to create an overall measure of the variable of interest. Descriptive statistics were computed to describe the qualified participants' characteristics. Numerical (Skewness, Kurtosis) and Kolmogorov-Smirnow test were performed to test the normality of the data and for any outliers. Baseline characteristics and measures for the treatment and control groups were compared using Chi-square test for categorical variables and independent *t*-test for continuous variables. The mixed model, which accounts for missing repeated measures, was performed with a two-level between group factor (treatment and control) and a two-level within factor (post 1 and post 2) repeated measures analysis of covariance (RM ANCOVA) to examine whether children playing Diab improved the health outcome compared to the control group. Separate models were used for each dependent variable controlling for age, gender, BMI, SocD, and baseline values of the variable of interest. The school random effects were also specified in the models. A significant group-by-time interaction indicated a difference in outcome over time between the treatment group and control group. Changes in post 1 and post 2 (minus baseline) were examined by using ANCOVA controlling for age, gender, SocD and baseline variables, respectively. The means and 95% CI of the treatment group relative to the control group, which were compared with Bonferroni tests, were reported as effect sizes.

To examine the contribution of immersion to the treatment effect, partial correlations were performed between immersion scale and change scores (post 1 or post 2

minus baseline) while controlling for age, gender, and BMI. Furthermore, participants in the treatment group were divided into high and low immersion subgroups according to whether their immersion scores were above or below the median (36) of possible scores (18 to 54). Changes in post 1 and post 2 (minus baseline) were examined by using ANCOVA controlling for age, gender, SocD and baseline variables, respectively. The means and 95% CI of the high immersion group relative to the low immersion group, which were compared with Bonferroni tests, were reported as effect sizes. A two-level, between group factor and a two-level within factor (post 1 and post 2) RM ANCOVA using mixed models adjusted for baseline outcome values and selected covariates (i.e., age, gender, SocD and BMI) were performed to examine the intervention effect between the high and low immersion groups across time.

Spearman correlations were calculated between the immersion scale and BMI to test whether there were intervention effects between non-overweight and overweight children. Similar statistical procedures were performed between the non-overweight and overweight groups with ANCOVA to test changes in post 1 and post 2 controlling for age, gender, SocD, and baseline variables, respectively. The means and 95%CIs of the non-overweight group relative to the overweight group, which were compared with Bonferroni tests, were reported as effect sizes. A two-level, between group factor and a two level, within factor RM ANCOVA was conducted to test the treatment effect between the two groups across time.

Additionally, analyses were conducted with all missing data imputed by using the Last Observation Carried Forward (LOCF) method. The findings were compared with participants who completed the entire study. All statistical analyses were performed using

SPSS 22.0 (IBM Corp, Armonk, NY), and a two-sided p value <.05 was considered statistically significant.

Results

One hundred and seventy nine children were recruited at baseline. After 8-10 weeks intervention, 92.7% had completed data at post 1 (n = 166) and 91.1% at post 2 (n = 163). The retention rate was 92.6% in the treatment group and 89.3% in the control group (*Figure* 6.1). Baseline characteristics indicated the study sample had 57.5% males and 33.0% overweight children. There were no significant differences in gender, BMI and body status between the treatment and control groups. Compared to the control group, the treatment group had more children aged 11~12 years ($\chi^2_{(1)} = 12.31$, $p = .002$) (Table 6.1). There were no differences in demographics or anthropometrics or between those retained and eliminated from the sample, or between participants with and without missing data. Little's chi-square test of all variables indicated that data were missing completely at random ($\chi^2_{(516)} = 95.91$, $p = .752$). At baseline, gender differences in self-efficacy for vegetable ($t_{(176)} = -3.23$, $p = .001$), preference for fruit, vegetable, and water ($t_{(176)} = -2.68$, $p = .008$), and objective PA levels ($t_{s(176)} > -3.23$, $p_s < .015$) were observed in the overall sample. However, no differences were found for all the baseline values in separate gender across the treatment and control groups, which indicate the comparability between two groups. Referring to the literature review, gender differences in the intervention effect were not reported as a key indicator. Given gender is not the concerned variable in this videogame-based intervention and the balance distribution in the treatment and control

groups at baseline, gender is set as a covariate in the subsequent analyses for intervention effect.

Most measures were normally distributed and were included in the analyses. No outliers were detected. Table 6.2 presents the results for all measures, stratified by group and time using mixed-model repeated measures ANCOVAs. Students in the treatment group had slightly more sedentary time (mean (SE): 612.2 (9.8)) than the control group (608.8 (11.4)) ($t_{(144)}$ = 3.49, p = .001). Mixed-model RM ANCOVAs were conducted to test for treatment effects by examining time × intervention interactions controlling for age, gender, BMI, SocD, and baseline assessment of the variable of interest. No significant treatment effects were found for all measures across time (p_S > .05).

Table 6.1.Children's demographic characteristics at baseline

	Overall (n = 197)	Treatment (n = 95)	Control (n = 84)	Statistics (χ^2/ t)	p value
Gender, n (%)					
Boys	103 (57.5)	57 (60.0)	46 (54.8)	0.50	.545
Girls	76 (42.5)	38 (40.0)	38 (45.2)		
Age (year), n (%)					
8~9	52 (29.1)	17 (17.9)	35 (41.7)		
10	42 (23.5)	25 (26.3)	17 (20.2)	12.31	.002
11~12	85 (47.5)	53 (55.8)	32 (38.1)		
Body status, n (%)					
Non-overweight	120 (67.0)	60 (63.2)	60 (71.4)	1.38	.155
Overweight	59 (33.0)	35 (36.8)	24 (28.6)		
BMI(kg/m2), mean[SD]	18.93 [3.72]	19.16 [3.76]	18.67 [3.69]	0.88	.381

At post 1, there were significant adjusted changes between the treatment and control groups in intrinsic motivation for fruit (adjusted change (95% CI): 1.6 (0.1, 3.1); $F_{(1)}$ = 4.52, p = .035, partial η^2 = .029), intrinsic motivation for water (adjusted change (95% CI): 1.2 (0.2, 2.3); $F_{(1)}$ = 5.11, p = .025, partial η^2 = .033), self-efficacy for PA (adjusted

change (95% CI): 2.4 (0.5, 4.4); $F_{(1)}$ = 6.31, p = .013, partial η^2 = .040), and PAQ-C (adjusted change (95% CI): 1.9 (0.3, 3.4); $F_{(1)}$ = 5.87, p = .017, partial η^2 = .038), which all increased in the treatment group but decreased in the control group. However, these significant adjusted changes were not detected at post 2 (Table 6.3).

Upon the completion of all Diab episodes, children in the treatment group reported an immersion score. Of the 90 intervention group children, 88 completed the 18-item immersion scale. Although the immersion score showed a wide distribution, ranging between 20 and 52, the average immersion score was 37.8 (SD: 9.2), to the right of center (36) of the range of possible score (18 to 54). Immersion scores were normally distributed (p = .167 for Kolmogorov-Smirnov test). Skewness (-0.19) and Kurtosis (-0.84) were lower than the absolute value of 1.0. Children achieved above the median amount of immersion in Diab.

Table 6.4 presents high- and low- immersion level means for the treatment group children at three time points. At baseline, there was slightly higher sedentary time in the high immersion group (mean (SD): 635.4 (68.0)) compared to the low immersion group (mean (SD): 595.3 (92.6)) ($t_{(76)}$ = 2.18, p = .032). To further explore the contribution of story immersion to the intervention effect, change in post 1 and post 2 (minus baseline) were examined in the high and low immersion groups by using ANCOVA with adjusted change as the effect size. At post 1, there were significant adjusted changes between the two groups in intrinsic motivation for fruit (adjusted change (95% CI): 2.2 (0.3, 4.2); $F_{(1)}$ = 5.09, p = .027, partial η^2 = .060), water (adjusted change (95% CI): 2.2 (0.7, 3.7); $F_{(1)}$ = 8.61, p = .004, partial η^2 = .097), autonomous motivation for PA (adjusted change (95% CI): 3.9 (0.3, 8.1); $F_{(1)}$ = 4.46, p = .047, partial η^2 = .041), and controlled motivation for

PA (adjusted change (95% CI): 4.6 (0.3, 8.9); $F_{(1)} = 4.55$, $p = .036$, partial $\eta^2 = .054$), which all increased in the high immersion group but decreased in the low immersion group. However, these significant adjusted changes were not detected at post 2. No significant treatment effects were found in all measures across the three time points by using the mixed model RM ANCOVA controlling for age, gender, BMI, SocD, and baseline values ($p_s > .05$). Partial correlations between the immersion scale with change score (post 1 or post 2 minus baseline) in autonomous motivation for PA at post 1 ($r = .27$, $p = .041$) was significant but not in changes of other measures in either time point ($p_s > .05$).

There was no significant correlation between immersion score and children's BMI in the treatment group ($p = .632$). The participants were classified to the non-overweight and overweight group to examine whether the intervention effects differed between the two groups. No significant adjusted change were detected in both post 1 and post 2 between two groups by using ANCOVA and no significant treatment effect was found in all measures across three time points by using mixed model RM ANCOVA ($p_s > .05$) (Table 6.5).

Table 6.2. Adjusted means (standard error) for measures, stratified by group and time using mixed-model repeated measures ANCOVA[a]

Dependent variables	Treatment group			Control group			Statistics			
							Group		Group × Time	
	Baseline (n = 95)	Post 1 (n = 90)	Post 2 (n = 88)	Baseline (n = 84)	Post 1 (n = 76)	Post 2 (n = 75)	*F*	*p*	*F*	*p*
Intrinsic motivation										
Fruit	23.8 (3.6)	23.9 (3.6)	23.4 (3.6)	24.5 (3.6)	23.2 (3.6)	23.4 (3.6)	0.05	.830	0.78	.457
Vegetable	17.3 (7.3)	17.5 (7.3)	17.1 (7.3)	18.4 (7.3)	17.4 (7.3)	17.0 (7.3)	0.33	.566	0.96	.385
Water	19.7 (0.4)	20.3 (0.4)	19.2 (0.4)	19.7 (0.5)	19.5 (0.5)	18.9 (0.5)	1.92	.166	0.38	.684
PA motivation										
Autonomous	39.9 (1.4)	40.7 (1.3)	40.7 (1.4)	42.7 (1.4)	42.4 (1.6)	41.3 (1.5)	3.52	.062	0.11	.893
Controlled	22.2 (1.6)	22.2 (1.6)	20.5 (1.6)	19.2 (1.7)	18.5 (1.8)	17.5 (1.8)	9.57	.002	0.04	.957
Self-efficacy										
Fruit	25.0 (0.9)	26.4 (0.9)	24.5 (0.9)	23.2 (1.0)	24.5 (1.0)	23.8 (1.0)	4.93	.027	0.34	.712
Vegetable	16.2 (0.6)	17.1 (0.7)	16.7 (0.7)	16.3 (0.7)	17.0 (0.8)	16.3 (0.7)	0.22	.643	0.11	.892
Water	11.6 (0.3)	12.1 (0.3)	11.8 (0.3)	11.5 (0.35)	11.6 (0.4)	11.2 (0.3)	3.01	.084	0.25	.777
PA	25.5 (0.8)	26.5 (0.8)	25.6 (0.8)	25.9 (0.8)	24.8 (0.9)	25.2 (0.8)	0.64	.425	0.84	.434
Preferences										
FVW	112.7 (1.7)	114.1(1.9)	116.2 (1.7)	113.4 (1.8)	115.1 (2.1)	117.0 (1.9)	0.80	.373	0.01	.991
PA	78.7 (4.4)	81.4 (4.5)	80.1 (4.5)	80.0 (4.4)	80.0 (4.5)	80.3 (4.5)	0.13	.721	0.50	.607
PAQ-C	23.7 (0.9)	24.9 (1.0)	24.4 (1.0)	25.2 (1.0)	24.6 (1.0)	24.2 (1.0)	0.27	.606	1.02	.362
Objective PA (minute)	(n = 85)	(n = 62)		(n = 62)	(n = 46)					
Sedentary [b]	612.2 (9.8)	608.8 (11.4)	-	561.4 (11.7)	553.1 (13.7)	-	22.3	<.001	0.05	.820
Light	156.2 (5.6)	157.1 (6.3)	-	151.7 (6.0)	158.7 (6.9)	-	0.76	.384	0.54	.462
MVPA	39.9 (1.8)	42.8 (2.1)	-	42.1 (2.0)	42.7 (2.4)	-	0.84	.361	0.36	.550

Notes: [a] Mixed model included the school random effect and controlled for age, gender, body mass index, social desirability, and baseline assessment of the variable.

[b] Indicates variables for which there were baseline differences.

PA, physical activity; FVW, fruit, vegetables and water; PAQ-C, physical activity questionnaire for older children; MVPA, moderate-to-vigorous PA.

Table 6.3. Means (SD) for measures at three time points stratified by group and time using ANCOVA

Dependent variables	Baseline		Post 1			Post 2		
	Treatment group (n = 95)	Control group (n = 84)	Treatment group (n = 90)	Control group (n = 76)	Adjusted change [a] Mean (95%CI)	Treatment group (n = 88)	Control group (n = 75)	Adjusted change [a] Mean (95%CI)
Intrinsic motivation								
Fruit	24.0 (5.1)	24.7 (4.0)	24.0 (5.7)	23.2 (4.4)	1.6 (0.1, 3.1)*	23.4 (5.2)	23.4 (5.1)	0.9 (-0.5, 2.4)
Vegetable	17.4 (4.1)	18.5 (3.6)	17.5 (4.9)	17.4 (3.9)	1.1 (-0.1, 2.4)	17.1 (4.4)	17.0 (4.1)	1.1 (-0.1, 2.2)
Water	19.9 (4.6)	20.0 (3.4)	20.3 (4.3)	19.6 (3.7)	1.2 (0.2, 2.3)*	19.3 (4.2)	19.0 (4.1)	0.7 (-0.5, 1.9)
PA motivation								
Autonomous	40.1 (12.7)	43.3 (9.9)	40.7 (13.4)	42.2 (12.0)	0.3 (-2.9, 3.6)	39.3 (13.2)	41.0 (12.7)	-0.3 (-3.4, 2.8)
Controlled	22.7 (12.3)	19.7 (8.5)	22.4 (12.1)	19.0 (10.9)	2.1 (-1.2, 5.5)	20.8 (11.8)	18.0 (9.6)	1.2 (-1.9, 4.3)
Self-efficacy								
Fruit	25.3 (6.7)	24.1 (6.6)	26.5 (6.7)	24.7 (7.1)	1.3 (-0.5, 3.1)	24.7 (7.6)	24.3 (6.8)	0.3 (-1.7, 2.3)
Vegetable	16.2 (4.7)	16.6 (4.9)	17.1 (5.5)	16.9 (5.2)	0.3 (-1.0, 1.6)	16.7 (5.3)	16.4 (4.8)	0.4 (-0.9, 1.8)
Water	11.7 (3.1)	11.7 (3.0)	12.1 (3.0)	11.5 (3.3)	0.5 (-0.4, 1.4)	11.8 (2.9)	11.3 (3.0)	0.6 (-0.2, 1.4)
PA	25.2 (7.6)	26.4 (6.9)	26.5 (7.4)	24.7 (7.6)	2.4 (0.5, 4.4)*	25.9 (7.5)	25.1 (6.8)	0.9 (-1.1, 2.9)
Preferences								
FVW	112.9 (16.8)	113.4 (16.5)	114.1 (19.3)	114.6 (15.3)	0.1 (-3.9, 4.1)	116.5 (16.7)	117.0 (15.0)	0.6 (-3.1, 4.3)
PA	78.5 (12.6)	80.2 (10.7)	81.6 (13.7)*	79.9 (11.9)	3.1 (-0.2, 6.3)	80.2 (13.5)	80.3 (12.7)	1.4 (-2.1, 4.9)
PAQ-C	23.5 (6.5)	25.1 (5.4)	24.9 (6.8)*	24.2 (5.6)	1.9 (0.3, 3.4)*	24.7 (6.6)	23.8 (6.2)	1.5 (-0.1, 3.1)
Objective PA (minute)	(n = 85)	(n = 62)	(n = 62)	(n = 46)				
Sedentary [b]	627.8 (78.1)	579.9 (73.5)	610.4 (90.9)	556.4 (70.4)	21.4 (-8.6, 51.4)	-	-	-
Light	158.7 (30.8)	166.0 (34.8)	152.7 (30.1)	162.2 (30.9)	-1.9 (12.8, 9.0)	-	-	-
MVPA	40.6 (10.8)	44.2 (15.4)	42.2 (13.3)	43.1 (17.3)	0.7 (-4.0, 5.5)	-	-	-

Notes: [a] Adjusted change means and 95% confidence intervals (CIs) are the differences of the treatment group relative to control group by ANCOVA adjusted for age, gender, body mass index, social desirability, and baseline assessment of the variable.

[b] Indicates variables for which there were baseline differences.

* $p < .05$

PA, physical activity; FVW, fruit, vegetables and water; PAQ-C, physical activity questionnaire for older children; MVPA, moderate-to-vigorous PA.

Table 6.4. Means (SD) for measures at three time points stratified by immersion score within treatment group using ANCOVA

Dependent variables	Baseline		Post 1			Post 2		
	High immersion (n = 45)	Low immersion (n = 43)	High immersion (n = 45)	Low immersion (n = 42)	Adjusted change [a] Mean (95%CI)	High immersion (n = 41)	Low immersion (n = 41)	Adjusted change [a] Mean (95%CI)
Intrinsic motivation								
Fruit	24.7 (4.9)	23.0 (5.2)	25.7 (4.6)	22.3 (6.0)	2.2 (0.3, 4.2)*	24.5 (4.1)	21.9 (6.0)	1.7 (-0.3, 3.7)
Vegetable	17.8 (4.1)	16.6 (3.9)	18.4 (4.5)	16.7 (5.1)	0.8 (-0.9, 2.5)	17.6 (4.5)	16.2 (4.3)	0.7 (-0.9, 2.3)
Water	20.0 (4.7)	19.5 (4.5)	21.4 (3.6)	18.9 (4.6)	2.2 (0.7, 3.7)*	19.8 (3.9)	18.2 (4.2)	1.4 (-0.1, 2.9)
PA motivation								
Autonomous	40.2 (12.8)	40.1 (12.8)	42.4 (13.9)	38.9 (12.6)	3.9 (0.3, 8.1)*	38.7 (13.7)	39.6 (13.3)	-0.3 (-4.2, 3.6)
Controlled	24.8 (13.0)	20.2 (11.3)	25.0 (12.6)	18.9 (9.5)	4.6 (0.3, 8.9)*	19.6 (10.4)	19.9 (12.3)	-2.4 (-6.9, 2.1)
Self-efficacy								
Fruit	25.4 (6.6)	24.7 (6.7)	27.8 (6.4)	25.3 (6.9)	2.4 (-0.1, 4.9)	25.2 (7.9)	23.3 (7.0)	1.9 (-1.0, 4.8)
Vegetable	16.3 (4.6)	15.8 (4.8)	17.3 (5.5)	17.1 (5.6)	0.1 (-1.7, 1.9)	17.0 (5.7)	16.0 (5.0)	0.9 (-0.8, 2.6)
Water	11.4 (3.4)	11.9 (2.9)	12.1 (3.1)	12.2 (2.9)	0.2 (-0.9, 1.3)	12.0 (2.9)	11.4 (2.9)	1.1 (0.1, 2.1)*
PA	25.7 (8.0)	24.3 (7.1)	26.8 (7.8)	26.3 (7.1)	0.0 (-2.2, 2.3)	25.0 (8.2)	25.8 (6.8)	-0.8 (-3.8, 2.2)
Preferences								
FVW	113.6 (15.3)	112.5 (18.2)	115.4 (20.8)	113.8 (17.0)	1.5 (-4.4, 7.4)	116.3 (17.5)	116.4 (16.4)	-0.1 (-5.4, 5.1)
PA	78.4 (13.8)	78.3 (11.4)	81. 24 (15.2)	81.6 (12.4)	0.1 (-4.3, 4.5)	79.2 (14.1)	79.8 (12.6)	0.2 (-4.6, 5.0)
PAQ-C	24.0 (7.1)	23.3 (5.6)	25.3 (7.5)	24.7 (5.9)	0.2 (-1.9, 2.4)	24.5 (7.2)	23.9 (5.6)	0.4 (-1.6, 2.4)
Objective PA (minute)	(n = 40)	(n = 38)	(n = 34)	(n = 28)				
Sedentary [b]	635.4 (68.0)	595.3 (92.6)	608.8 (102.5)	614.1 (74.8)	-17.9 (-56.6, 20.8)	-	-	-
Light	163.2 (32.4)	152.6 (31.4)	158.6 (29.5)	146.5 (31.3)	0.2 (-14.6, 14.9)	-	-	-
MVPA	42.0 (11.6)	39.5 (10.9)	41.2 (10.4)	43.6 (16.0)	-2.5 (-9.2, 4.1)	-	-	-

Notes: [a] Adjusted change means and 95% confidence intervals (CIs) are the differences of the high immersion group relative to low immersion group by ANCOVA adjusted for age, gender, body mass index, social desirability, and baseline assessment of the variable.

[b] Indicates variables for which there were baseline differences.

* $p < .05$

PA, physical activity; FVW, fruit, vegetables and water; PAQ-C, physical activity questionnaire for older children; MVPA, moderate-to-vigorous PA.

Table 6.5. Means (SD) for measures at three time points stratified by body weight status within treatment group using ANCOVA

Dependent variables	Baseline		Post 1			Post 2		
	Non-overweight (n = 59)	Overweight (n = 35)	Non-overweight (n = 56)	Overweight (n = 34)	Adjusted change [a] Mean (95%CI)	Non-overweight (n = 54)	Overweight (n = 34)	Adjusted change [a] Mean (95%CI)
Intrinsic motivation								
Fruit	23.5 (5.4)	24.7 (5.1)	24.1 (5.7)	23.7 (5.7)	0.5 (-1.7, 2.8)	23.4 (4.6)	23.6 (6.1)	0.4 (-1.6, 2.4)
Vegetable	17.3 (4.1)	17.6 (4.1)	17.6 (4.7)	17.2 (5.2)	0.5 (-1.4, 2.3)	17.1 (3.7)	17.2 (5.3)	0.1 (-1.4, 1.6)
Water	19.6 (4.4)	19.9 (5.4)	20.9 (4.2)	19.3 (4.3)	1.3 (-0.3, 2.9)	19.1 (3.5)	19.5 (5.1)	-0.4 (-1.9, 1.2)
PA motivation								
Autonomous	40.3 (12.3)	39.4 (14.0)	41.9 (12.3)	39.1 (14.7)	1.6 (-2.9, 6.0)	40.1 (12.6)	38.2 (14.2)	0.4 (-3.6, 4.4)
Controlled	23.4 (12.6)	20.6 (11.7)	24.1 (13.2)	19.8 (9.2)	2.3 (-2.5, 7.0)	21.7 (11.5)	19.5 (12.1)	1.5 (-3.3, 6.3)
Self-efficacy								
Fruit	24.7 (6.6)	26.1 (6.9)	26.9 (6.2)	26.0 (7.5)	0.7 (-1.9, 3.2)	24.9 (7.0)	24.5 (8.5)	0.7 (-2.3, 3.8)
Vegetable	16.2 (5.0)	16.2 (4.7)	17.6 (5.4)	16.3 (5.5)	0.6 (-1.3, 2.5)	16.9 (5.4)	16.5 (5.3)	0.1 (-1.7, 1.8)
Water	11.5 (3.0)	11.9 (3.5)	12.1 (2.6)	12.1 (3.5)	0.1 (-1.0, 1.3)	12.1 (2.6)	11.2 (3.3)	1.0 (-0.1, 2.1)
PA	25.9 (7.8)	24.9 (8.0)	27.6 (6.7)	25.1 (8.3)	1.7 (-0.6, 4.1)	26.0 (7.1)	25.7 (8.3)	-0.1 (-3.0, 2.9)
Preferences								
FVW	111.0 (17.8)	116.0 (14.0)	113.4 (19.4)	115.6 (19.1)	-0.4 (-6.6, 5.8)	115.4 (17.8)	118.4 (14.7)	-1.7 (-6.9, 3.5)
PA	78.6 (12.9)	79.3 (13.0)	82.3 (14.1)	79.9 (13.5)	2.6 (-2.1, 7.2)	81.6 (12.8)	77.8 (14.4)	3.6 (-1.2, 8.4)
PAQ-C	23.8 (7.3)	23.7 (5.6)	25.4 (6.9)	24.3 (6.2)	0.8 (-1.5, 3.0)	25.1 (6.6)	24.0 (6.5)	0.6 (-1.5, 2.8)
Objective PA (minute)	(n =58)	(n = 27)	(n = 46)	(n = 16)				
Sedentary [b]	614.8 (79.9)	609.9 (87.7)	620.3 (87.7)	585.0 (96.4)	49.3 (8.3, 90.3)	-	-	-
Light	153.9 (29.2)	166.3 (35.1)	149.6 (32.5)	163.2 (22.7)	-1.5 (-17.7, 14.8)	-	-	-
MVPA	40.4 (11.9)	40.0 (10.3)	42.9 (14.3)	40.2 (9.2)	3.2 (-4.1, 10.5)	-	-	-

Notes: [a] Adjusted change means and 95% confidence intervals (CIs) are the differences of the non-overweight group relative to overweight group by ANCOVA adjusted for age, gender, social desirability, and baseline assessment of the variable.

[b] Indicates variables for which there were baseline differences.

PA, physical activity; FVW, fruit, vegetables and water; PAQ-C, physical activity questionnaire for older children; MVPA, moderate-to-vigorous PA.

In addition, the analyses were conducted with imputed data using LOCF method. The results on the outcomes were in line with those reported above among the participants who provided complete data (data not shown).

Wearing accelerometers was not considered uncomfortable to participants. Two children reported that the earphones were too tight. Two children felt slightly dizzy during one session when playing a difficult level. No other adverse events were reported.

Discussion

The childhood obesity epidemic is a global burden that has been rapidly increasing in both developed and developing countries. The need for effective intervention strategies has informed the design of innovative technology which has been applied in this comprehensive intervention. As such, the current pilot study is a valuable contribution to research exploring behavior modification strategies by using health videogames with story immersion for Chinese childhood obesity. This intervention aimed to investigate the effect of a health videogame with story immersion. There were significant improvements in intrinsic motivation for water, self-efficacy for PA, PA preference and PAQ-C scores in the treatment group at post 1. However, these improvements were not detected at post 2. Further explorations of the potential contribution of story immersion in Diab revealed that intrinsic motivation for fruit and water, autonomous and controlled PA motivation increased in the high immersion group, but decreased in the low immersion group at post 1. Similar to the main findings, these improvements of psychological correlates was not sustained at post 2. No significant treatment effects between the non-overweight and

overweight children were detected. The findings indicate a short-term effect of Diab for childhood obesity prevention among Hong Kong Chinese children.

Hypothesis 1: Playing Diab would improve children's self-efficacy, motivation and preferences for diet and PA and subsequent health behaviors.

Video games create a virtual environment and can make users feel fully immersed in the game and consequently experience a high degree of control which impacts on their virtual environment (McMahan, 2003). Players react strongly when they first experience immersive virtual reality. Seeing the stereoscopic graphics of the video game, picking up virtual objects with their real hands, realizing their role and identity shifts all provide a unique experience (Bowman & McMahan, 2007). Compared to console gaming, video games in immersive virtual realities are considered effective because they provide a more realistic experience (Dede, 1995). In this study, it was hypothesized that playing Diab, a health videogame with an immersive story, could improve children's motivation, self-efficacy, and preference for diet and PA behaviors. The improvements in intrinsic motivation for water, self-efficacy for PA, PA preference and PAQ-C in the treatment group were observed immediately after playing the game, while these psychological correlates decreased in the control group. The results reveal that Diab motivated children to some extent and have short-term beneficial effects on psychological outcomes.

The current intervention aimed to increase motivation, other subjective states conceptually related to motivation (i.e., self-efficacy and preference), and the related behaviors. Receptiveness refers to the extent to which participants' behavior was endorsed by the increased level of motivation (Bellg et al., 2004). SDT posits that motivation helps individuals initiate and maintain behavior and more self-determined

forms of motivation lead to optimal functioning and well-being (Ryan & Deci, 2007). Self-efficacy is considered as a predictor of health behavior change and maintenance (Strecher et al., 1986). Bandura (1977) outlined the role of self-efficacy in a model where the individual engages in a behavior that has a consequent outcome. As such, perceived motivation and self-efficacy can influence aspects of behavior. In the current study, self-efficacy for PA improved from 25.2 (SD: 7.6) at baseline to 26.5 (SD: 7.4) at post 1. The PA preference increased in the treatment group as well, from 78.5 (SD: 12.6) at baseline to 81.6 (SD: 13.79) at post 1. Despite the fact that some psychological correlates improved at post 1, the objective PA level did not demonstrate a positive change, which may be attributable to the significant but slight improvements of these predictors. It is possible that the increasing magnitude of self-efficacy was not powerful enough to engender a behavior outcome as expected. Kelly and colleagues (1991) found that behavior change was poorly predicted by self-efficacy for most lifestyle areas. Health-compromising behaviors such as PA and poor dietary habits are difficult to change, and although it is assumed that an individual's intention to change is the best predictor of actual change, people often do not behave in accordance with their intentions and motivations. This discrepancy may be due to several factors, for example, unforeseen barriers and environmental influences (Schwarzer, 2008).

Regarding the lasting effects of the treatment, the maintenances of improvements in the psychological correlates were non-existent at follow up test which was 8-10 weeks without exposure to the game. This may be because that the short-term improvements on indicators were insufficient to encourage the children to maintain beneficial effects after disconnecting from Diab. The number of episodes played represents program dose, and

this is the amount of intervention content to which the participants were exposed (Linnan & Steckler, 2002). In the development of video games by Archimage, Inc, the concept of energy balance was divided into 18 component skills to be learned sequentially. The first nine skills were inserted into the Diab episodes and the other nine were inserted into the "Nanoswarm: Invasion from Inner Space" (Nano) episodes, which were designed by the same expert team that created Diab. A study by Baranowski et al. (2011) demonstrated positive effects on children's fruit intake by playing both Diab and Nano. However, in the present study, due to the limitation of the schools' schedules, only Diab was completed. Previous reviews of prevention program have suggested that longer duration, multi-session interventions produced superior effects than brief interventions since longer intervention afford a greater opportunity for presenting the information and enhancing behavioral change skills (Elder, Ayala, & Harris, 1999). More episodes and longer duration should be considered in future to enhance the dosage and intensity of the treatment.

Hypothesis 2: The high story immersion in children's response to exposure to Diab would engender a more beneficial effect.

A higher level of immersion could produce a greater sense of presence, which refers to a user's subjective psychological response to a virtual system and relates to the experience of "being there". Thus, higher immersion could produce a greater psychological impact and subsequently generate more stimulation for the real-world (Slater, Linakis, Usoh, Kooper, & Street, 1996). In the present study, immersion scores were positively related to changes in autonomous motivation for PA at post 1 in the treatment group (r = .27). Children with high immersion scores had a greater increase in

autonomous motivation for PA, which has been identified as a positive predictor for PA in the study 2. Furthermore, analyses of intervention effects were performed between the high and low immersion subgroups. The subgroups were classified by immersion scores higher or lower than the median (36) of possible scores (18 to 54). Several psychological correlates (i.e., intrinsic motivation for fruit and water, autonomous and controlled PA motivation) improved in the high immersion groups, and reduced in the low immersion group at post 1. Similar to the findings between the treatment and control groups, the improvements at post 1 were not sustained at post 2. This finding poses a question regarding the sustained effect of story immersion. In a review investigating the maintenances of childhood obesity interventions indicated similar finding with regards to disappointing long-term effects (Jeffery et al., 2000). The pattern of evidence of effectiveness over time suggests there is a need for an increased focus to support behavior change maintenance (Dansinger, Tatsioni, Wong, Chung, & Balk, 2007).

Video games provide an important interaction with players through the characteristics that make the narrative personally relevant (Green, 2004). For characters to serve as models for audiences, their perceived similarity and competence are important (Schunk, 1986). Compared to adults, children are more receptive to the story in the game. Children as a group have a rich imagination which could be more influenced by media context if they perceive themselves to be similar to the characters (Burnstein, Stotland, & Zander, 1961). In Diab, the characters were created to have diverse appearances with different genders, racial origins, body sizes and shapes, facial features and personalities. However, all these characters featured African-American and Hispanic children. After playing Diab, Hong Kong children achieved average immersion with mean scores of 37.8

(SD: 9.2), which was lower than a prior Diab study of US children (mean (SD): 40.8 (8.2)) (Lu, Thompson, et al., 2012). Even though the game demonstrated acceptability and applicability among the Hong Kong Chinese children, the possible differences in the recognition of cultural identity between Asians and African-American and Hispanics could have lowered the immersion level and limited the intervention effect.

One goal of treatment fidelity strategies for the monitoring and improvement of the receptiveness of the treatment is to ensure participant comprehension, which means that all participants understand the information provided during the intervention, especially when participants are cognitively compromised, or not proficient in English (Bellg et al., 2004). According to the findings of the interview phases, the majority of participants indicated no great difficulties in the comprehension of the English language in Diab. Although conversations within the game were not considered difficult and a translation of food and PA vocabulary was provided on a multimedia screen during the play sessions, Hong Kong children as non-native speakers may still have encountered problems with specific content, which could have influenced the children's interaction with the game.

Hypothesis 3: As a high-risk group, overweight children would be more motivated during the intervention and therefore more likely to benefit from the treatment than their healthy weight peers.

Generally, it is hypothesized that interventions offered to high-risk participants are more effective compared to offering the same intervention to all individuals in a population (Stice & Shaw, 2004). Selected interventions have been conducted with various groups of participants at elevated risk for possible future weight-gain, such as children with cardiovascular disease risk factors, overweight or obese individuals. In the

obesity prevention field, there is the possibility that overweight participants have a stronger intention to improve than non-overweight children, and that an intervention conducted with a higher-risk group may result in larger positive effects (Stice, Shaw, & Marti, 2006). In the Ledoux and colleagues' (2011) review, most interventions showing positive effects were among samples with a minimum of participants above the 85th BMI percentile. However, no significant treatment differences were found between the overweight and non-overweight children in the present study.

With the rapid increase in overweight and obesity in Hong Kong, a large number of interventions have been launched and implemented, such as the School Lunch Program (Chan, 2008), Health Promotion Schools (Lee, Cheng, Fung, & St Leger, 2006) and other education programs (Lau & Hue, 2011; Lee, Tsang, Lee, & To, 2003). The School-family-community partnership that has been developed in Hong Kong has enhanced communication about children's social learning (Pang, 2004). Due to an increase in the influence from various social mediums, for example, the media, peer- and parental influence, school education regarding childhood obesity prevention, overweight and obese children could easily acquire knowledge about healthier diet and PA from multiple channels. Considering the potential benefits of story immersion, which include the increasing bandwidth of useful information and awareness, the immersion effect may be limited by the vast amount of information already available to children. Therefore, more attention should be placed on how to translate overweight children's information and knowledge into improved attitudes that could subsequently have a beneficial effect on the adoption of healthier dietary and PA behaviors. One study that examined the weight-related concerns and behaviors of over 10,000 Hong Kong children, indicated that

although obese children had more concerns about their weight and wished to be lighter, they did not make more effort to lose weight than overweight children (Wong et al., 2005). Therefore, further attention should be placed on psychological stimulation and behavioral modification among high-risk children.

Generally, even overweight and obese children have a stronger intention to improve their diet and PA behaviors than their healthier peers, the control over their behaviors (e.g., unhealthy eating pattern, insufficient PA engagements) were weak. More effort should be paid for overweigh and obese children since fighting temptation and keeping weight off are difficult for them (Schifter & Ajzen, 1985). Without parental involvement may limit the intervention effect in the current study. Children have two meals at home and exercises after school account for a high percentage of their leisure activities. Availabilities of fruit, vegetable, and water at home also influence children's decision on food intake. Thus, parenting plays an important role in fostering children's behaviors and reshaping their weight status. Therefore, the future studies can be conducted with parental involvement.

Strengths and limitations

There are several noteworthy features of the current intervention. It is well demonstrated that physical activity and dietary interventions are effective components for childhood obesity prevention and that combined diet-plus-exercise program could provide greater weight-loss effects (Greaves et al., 2011). Diab provided both dietary and PA components to the children, and the intervention was a comprehensive intervention targeting childhood obesity. Furthermore, although most measures in the current study involved self-reported data, social desirability was measured and included in the analyses

as a covariate, which could control for the error of self-reported data (Klesges et al., 2004). PA was also measured with accelerometry, which is an accurate and reliable tool for quantifying PA behavior in children and adolescents (Riddoch et al., 2009).

The limitations of this study should be noted. Firstly, considering the practical issue with participating schools, this study was nonrandomized which may threaten internal validity and affect the generalizability. Since this study was a school-based intervention, the time arrangements had to take into account the semester system in Hong Kong. To avoid the long interval of the school holidays, the intervention was implemented within one semester and the recruitment procedure had to been conducted in the semester prior to the arrangement of play sessions. Therefore, some children who had returned consent letters had schedule conflicts with the arranged play sessions. Due to the limitation of sample size and the requirement of school principals and teachers, these students were not excluded, instead, were assigned into the control group. However, further investigation found that part of the reason children could not attend the play session was because they had other extracurricular classes or sport clubs, which meant the control group was not a completely blank control. This could somewhat underestimate the current intervention effects. In addition, despite there being no significant differences in questionnaire indicators at baseline between the treatment and control groups, initial differences in sedentary time behaviors may impair the detection of any changes. As such, the ability to make strong conclusions regarding the efficacy of this health videogame is difficult.

Secondly, the treatment and control conditions were held at the same school, which may result in the contamination. In a trial of PA and diet change, children in the control

group might talk with children in the intervention group or learn about the experimental treatment and then adopt it themselves, Cluster randomized trials, in which participants are allocated to different conditions, are often advocated to minimize contamination between treatment and control children (Torgerson, 2001). In future, cluster randomized trials is suggested to further explore the Diab intervention effect.

Thirdly, this study aimed to conduct an intervention which focused on both sides (diet and PA) of the energy balance equation. However, in the present study, only psychological variables of diet (i.e., motivation, self-efficacy, and preference for diet) were assessed. Dietary behaviors were not measured due to operational issues. With technological limitation (unavailability of software for the diet components analysis), diet intake were not conducted. It is difficult to involve parents in this school-based intervention to help children to recall the food intake frequency, which cannot be completed by children independently. Thus, the relationship between the psychological correlates and dietary behaviors could not be explored and the treatment effect on the dietary behavior aspect was not examined, which limits the overall evaluation of the Diab intervention.

Furthermore, the frequency and duration of the intervention was not equal although the intervention delivery was at same content with 9-episodes Diab. Of the four participating schools, two had one play sessions (1.5 hours per session) each week and the other two had two sessions (40 minute per session) each week. The similar intervention in USA was conducted in home-setting. The range of days for players to complete the game was 18-132 days (Lu, Thompson, et al., 2012). Regarding the intervention character, it was an individualized trial rather than the population training or

education session, however, the treatment effect may still be influenced by this unstandardized treatment protocol. Further efforts should be made to ensure that the equivalent dosage across the treatment conditions should be applied. For example, all participants should have an equal amount of contact with the intervention, and this should be conducted within an equal duration of time.

Lastly, participants' receptiveness of the treatment involved monitoring processes and the evaluation of the ability of participant to understand and preform treatment-related behavioral skills during treatment delivery. It is important to conduct measures of processes that take into account the exposure of information (May, Mair, Dowrick, & Finch, 2007). In Diab, goal setting is a multistep process in which the player was offered a choice of behaviors from which to set goals and to connect these goals to personal values. Players could choose specific goals that they wanted to work on and the number of days in which to attempt this goal. This is in line with the suggestion that pediatric weight management programs should emphasize realistic goals (Nemet et al., 2005). However, in the interview phase, only 15 out of 34 children set goals for each episode and 6 set part-goals. Although the findings of the individual interviews suggest to conduct the monitoring of the completion of goal setting in the intervention phase, due to manpower constraints, we did not evaluate whether participants had completed this goal-setting component in a manner that would be beneficial to them. In future, the goal-setting evaluation should be taken into account as one factor to conduct subgroup analyses and to minimize the possibility of bias and error in the interpretation of the findings from statistical approaches on treatment analyses.

Conclusion

Compared to other commercial video games, Diab was designed as a narrative adventure videogame with nine episodes. It is an entertaining but serious, theoretically grounded health videogame. A diversity of behavior change components were incorporated into the game. This study of Hong Kong Chinese children found that Diab partially motivated children to improve their motivation, self-efficacy and preference for diet and PA behaviors immediately after completing nine episodes of the game. However, this effect was not maintained 8-10 weeks later. Health videogames with appealing characters and immersive stories have the potential to provide an innovative medium for children's behavior change, however their lasting effectiveness and mechanisms of change require more thorough investigation.

CHAPTER 7 GENERAL DISCUSSION

This discussion will summarize the main finding from each chapter in this thesis and highlight the strengths and limitations of this research. The applications of the study and recommendations for future research will be discussed.

Summary

Chapter one illustrated the global issue of childhood obesity, and described the prevalence, correlates and treatments for childhood obesity. Technologies are now becoming rapidly integrated into people's lives and have made it possible for individuals to engage in sophisticated, simulated entertainment, education, and social interaction environments (Kirriemuir, 2002). G4H are serious video games that focus on health and target prevention and disease management (Baranowski, Baranowski, Cullen, Marsh, Islam, Zakeri, Honess-Morreale, et al., 2003). In a model of how video games with component change procedures influence mediators to change behavior, story immersion was identified as one of the front end components of the effect chain, which acts on the motivation to continue playing (Baranowski, Baranowski, Thompson, & Buday, 2011). Therefore, health videogames with appealing characters and immersive stories have the potential to provide an innovative medium for children's behavior change (Baranowski, Baranowski, Thompson, Buday, et al., 2011).

Chapter two reviewed the application of video games to improve children's obesity-related outcomes. This review provided a more comprehensive, age-specific and quantitative synthesis of the current state of health videogame-based intervention studies

targeting aspects of diet and PA in children and adolescents. The review demonstrated the effects of interventions by using health video games at the psychological correlates. However, limited evidence is available to draw conclusions on the consequent efficacy of behavioral modification. Considering the risk of obesity which results from an imbalance between energy intake and expenditure, obesity interventions should use a two pronged approach (Butte, Christiansen, & Sørensen, 2007). However, there is insufficient information with which to examine the dietary aspect of video game-based interventions in the present review. As a result, a reasonable next step was to conduct an intervention using a health videogame targeting both diet and PA to test its effects on psychological correlates and behaviors.

Chapter three described the validation study of the PAQ-C, which was applied to the subsequent studies to assess children's self-reported PA. Self-report questionnaires remain the most widely used and accepted methods in large populations due to their low cost to investigate and low burden to the participant. Moreover, contextual items on questionnaires provide information regarding activity type which is not easily captured through objective measurements (Matthews & Welk, 2002). The availability of validated, self-report PA measures is limited in Chinese pediatric populations. The PAQ-C has been identified as a valid instrument for use with Western children and adolescents (Chinapaw et al., 2010) but not among Chinese children. Good internal consistency and test-retest reliability suggest that the PAQ-C is an adequately reliable instrument for use among Chinese children. The significant moderate correlation between the PAQ-C score and accelerometer measured MVPA support its acceptable validity. The ease of use, low cost

for investigate and low burden to the participant make the PAQ-C applicable for use in large-scale PA studies among Chinese children.

Given the physical inactivity epidemic in China, understanding the association between psychological correlates and PA could inform the development of more efficacious interventions. SDT provides valuable insight into how to foster increments in autonomous motivation, and suggests that more self-determined forms of motivation should lead to optimal functioning and well-being (Ryan & Deci, 2007). SCT (Bandura, 1986) integrates cognitive, behavioral and environmental influences to predict behaviors. Self-efficacy is known to be a significant positive predictor of exercise adherence (McAuley & Blissmer, 2000). In addition, preference for PA was identified as a significant predictor of engagement in PA in a large community-based sample of adults (Salmon et al., 2003). However, there is a paucity of research on PA motivation, self-efficacy and preference among underserved Chinese children in free living conditions. Therefore, chapter four presents a study examining the associations among these psychological correlates with both self-reported and objective PA in Chinese children. Additionally, this study sought to examine whether these associations varied by different methods of assessing PA, controlling for social desirability. In a hierarchical regression model, age, PA self-efficacy, preferences, and autonomous motivation positively predicted PAQ-C score after controlling for gender, BMI, and SocD. However, age and PA preference did not contribute significantly in the hierarchical model predicting objectively assessed MVPA. Instead, objectively assessed MVPA was positively predicted by PA self-efficacy and autonomous motivation, and negatively predicted by gender. Although these prediction differences were found, which is likely due to self-

reported error variance common to the PAQ-C and psychological correlates but not to accelerometry, the findings of this chapter were considered helpful in order to identify predictors when assessing the subsequent intervention effect.

In chapter five, an individual interview was conducted with 34 Hong Kong Chinese children to collect children's personal thoughts on the health videogame "Escape from Diab." The interview assessed the acceptability and applicability of Diab among Hong Kong Chinese children, and explored whether the story in Diab was understood, and whether the story has any potential to influence their diet and PA behaviors both during and after playing the games. The results demonstrated that Diab was perceived as an immersive game by the majority of the participating Hong Kong Chinese children. Four themes emerged from the interviews including intuitive feelings about the interface, playing experience, perception of the effect of Diab on behavior change, and the applicability of Diab to Hong Kong children. The results also indicated that story immersion was a perceptible component and that Diab, originally developed for American children, was perceived as acceptable to the Hong Kong Chinese children. Therefore, as video games become a popular form of entertainment, Diab could be considered an innovative channel through which it may be possible to motivate healthy diet and PA behaviors which, in turn, may contribute positively towards the childhood obesity epidemic.

In chapter six, a pilot quasi-experimental study was conducted targeting both diet and PA. This study aimed to improve Hong Kong Chinese children's psychological correlates and behaviors Results revealed that Diab motivated children in the treatment group to improve their intrinsic motivation for water, self-efficacy for PA, PA

preferences, and self-reported PA behaviors immediately after completing the game. At post 1, improvements in intrinsic motivation for fruit and water, autonomous and controlled PA motivation were found in the high immersion group, but these were not found in the low immersion group. However, the positive effects were not sustained when measured 8-10 weeks later at post 2. No significant treatment differences were found for all measures between non-overweight and overweight children. As a result of the findings, it is suggested that health videogames, such as Diab, with appealing characters and immersive storylines, provided innovative mediums for children's obesity-related outcomes. However, their lasting effectiveness and the underlying mechanisms of change require to be investigated more thoroughly.

Strengths of the Study

This is the first research investigating health videogame effects among Chinese children. This research has validated the PAQ-C for use in Hong Kong Chinese children which contributes to the PA measurement of Chinese children in future. Furthermore, the associations between psychological correlates and PA behaviors have been examined using both self-report and objective PA measures, which provide valuable insight into the discrepancy between these types of PA measurement. Additionally, the identified psychological predictors of PA provide valuable information to guide the development of more efficacious interventions. Finally, the Diab intervention was comprehensively designed targeting both dietary and PA components to further explore childhood obesity prevention in Chinese children.

Limitations of the Study

Participants in all studies were volunteers, which may have resulted in a "self-selection" bias, thereby limiting the ability to generalize the findings. Although participants' age, BMI, gender, and SocD were statistically controlled in the cross-section and intervention analyses, other socio-demographic variables that were not considered in this research, such as parental education, household income, and peer influence may be potential confounders.

Considering participants' English comprehension abilities prior to the Diab intervention study, only children aged 8~12 years from EMI schools were recruited. Older adolescents may have lost interest in the video game and younger participants may have had greater English comprehension problems. As a result, having conducted the study within this specific age range limits the application of the intervention.

Due to the practical difficulties related to conducting the intervention, it was non-randomized design and the sample size is small, both of which have an impact on the internal and external validity of the conclusions (Onwuegbuzie, 2000). Furthermore, the dietary behavior aspect was not examined due to technological limitations. Finally, intervention progress evaluation was not conducted and as a result there is insufficient information regarding the intervention effect.

Theoretical implication of the study

SDT takes the important role on the individual functioning and well-being through the influences by the three basic psychological needs: relatedness, autonomous, and competence. Children's behavioral willing could be motivated from amotivation, external

and internal motivation. SDT has been applied in various aspects in Hong Kong Children, including school bullying (Lam, Law, Chan, Wong, & Zhang, 2015), creative thinking (Liu et al., 2013), and academic achievement (Law, 2011). However, there is limited study with the integration of SDT in childhood obesity prevention. Ha and colleagues (Ha, Lonsdale, Ng, & Lubans, 2014) published the protocol on a school-based rope skipping intervention for Hong Kong adolescents in 2014. The study aimed to increase participants' time spent in MVPA through inserting a 15-minute rope skipping activity in four consecutive PE lessons. Motivational factors extracted from SDT would be evaluated by comparing changes in the proportion of lesson from baseline to follow-up across the experimental and control groups. The intervention effect has not been reported.

As one of the most applied theory, self-efficacy also has been integrated to children's mental health through resilience (Ho, Louie, Chow, Wong, & Ip, 2015), mentorship program among underprivileged Hong Kong children (Ng, Lai, & Chan, 2014), and cancer and its treatment on PA levels (Chung, Li, Chiu, Ho, & Lopez, 2014). Associations among self-efficacy and PA behaviors have been explored already in the cross-sectional studies.

Although the previous studies were found to test the psychological influence for obesity-related behaviors, the current intervention is of the first studies among Hong Kong Chinese children to evaluate the treatment effect with integration of theoretical constructs of SDT and self-efficacy. Research indicates that theory-based interventions successfully influence PA behaviors. However, how these interventions were effective in promoting behaviors remains understood (Lewis, Marcus, Pate, & Dunn, 2002). As

proposed in the model of Baranowski et al. (2011), the psychological influence could be mediator to behavior changes in a cause-effect pathway. The role of mediators in successful interventions is recommended to evaluate by specifying which mediators are targeted. In the current study, motivation and self-efficacy for fruit, vegetable, water, and PA were improved practically after playing Diab. However, based on these limited intervention effects, there is no enough support to further explore the mediation effects of motivation and self-efficacy in Diab treatment. To some extent, this study demonstrates the importance of the theoretical constructs. The study also implicates the need to examine the mediation effects of these theoretical components in obesity-related interventions in future research.

Practical Implication of the Study

Due to diet and other sociopsychological changes, childhood obesity is an emerging problem, particularly in high-income and urban areas in China. Hong Kong, as one of highly urbanized society, with Western diet behaviors and fast lifestyles, more attention should be drawn to preventing the high rate of childhood obesity. A study on cultural differences in the value of moderation on gender, actual-ideal body image discrepancies and physical self-concept in Hong Kong and Western children indicated that results from Hong Kong differed from typical results from Western countries (Marsh, Hau, Sung, & Yu, 2007). In the study, Australian children, especially among girls, paid more emphasis on being thin, which would have a substantial effect on their self-concepts (e.g., self-esteem). On the contrary, Hong Kong children place less emphasis on being thin, and less impact of body image on their self-concepts and self-esteem were found. The results

reflected different Chines cultural value in obesity. It seemed that obesity in Hong Kong was apparently more acceptable than that in Western culture. This may account for general inadequacies of health education and promotion about the health risks resulted from obesity. The findings call for more intervention studies among Hong Kong children with consideration of cultural differences.

Diab, from Western country, was applied in the current intervention. Even the acceptability and applicability of Diab has been demonstrated in Hong Kong children, the dynamic processes of character identification and situation reproduction might be affected by the cultural adoption. The obvious difference in playing the game was the completion of goal setting. In Diab, goal setting is inserted for a component to behavior-change procedures. Goal setting had been already integrated in reducing drug abuse (Cheung & Ngai, 2013) and tobacco use (Ziedonis et al., 2012) among Hong Kong youth , however, no study was found to integrate it on obesity prevention. As a key self-regulatory procedure, the role of goal setting in Diab could be maximally aroused in further study. The status of completing goal-setting should be recorded to provide more intervention information.

Furthermore, parenting has been analyzed in the development of childhood overweight and in obesity prevention (Lindsay, Sussner, Kim, & Gortmaker, 2006). As children, particular students in primary schools, do not always have full control over their own diet behaviors. Hong Kong is a very densely populated city with limited outdoor space to engage in activity, which may lower children's willing to exercise. The safety of outdoor activities also is one of concerns of parents. In this case, parents are key to developing a home environment that fosters healthy eating and PA among youth.

However, this school-based study did not involve parents, which may limit the treatment effects. Future study could consider the implementation of Diab intervention at home setting and get parents involvement to shape their children's behaviors.

Additionally, this study recruited both overweight and non-overweight children, and partial intervention effects could be observed. Both groups reported similar low PA levels, so a ceiling effect for one group or other group was not operative here. In future, when implementing the similar study among normally healthy children, the ceiling effect for the treatment should be drawn careful attention. Since the normally healthy children who have healthy diet or engaged in sufficient PA, there is limited potential of improvement to act on.

Practical Application of the Study

Video game entertainment is prevalent in contemporary culture and society and fully integrated into the everyday lives of many of our young people. Published studies have gradually started to focus on the more interesting alternative aspect of video games, that of their educational potential as teaching and learning tools (De Aguilera & Mendiz, 2003). Videogames have been used in schools to teach education content (Watson, Mong, & Harris, 2011), convey nutrition information (Baranowski, Cullen, et al., 2003), for alcohol and drug awareness (Klisch, Miller, Beier, & Wang, 2012; Klisch, Miller, Wang, & Epstein, 2012), and education about hygiene (Farrell et al., 2011). The present research using Diab contributes to childhood obesity prevention, in the school setting, specifically targeting diet and PA. Video games used in education are labeled "Parallel Schooling", and offer an uninterrupted flow of miscellaneous signs and symbols transmitted via

specific stories and activities within the game (De Aguilera & Mendiz, 2003). As a result of the current findings, Diab could be applied in a school education program as an innovative and attractive medium through which to deliver diet and PA knowledge and behavioral modification components.

Future Research

Firstly, future research is recommended to address methodological limitations of the study.

1) Future studies with larger sample sizes would allow further exploration of treatment outcomes and reduce the rate of attrition.

2) Trials using random assignments to condition may produce larger intervention effects than those with alternative approaches to allocate participants to treatment or control conditions, and minimize the influence of confounding variables.

3) Future trials with process-based outcome measures, longer (with 18 episodes of Diab and Nanoswarm) and more intense interventions, as well as broader outcome measures including dietary behaviors, are suggested.

4) Active control groups with alternative common video games without an immersive storyline could fully explore the effect of story immersion in childhood obesity prevention.

Furthermore, apart from schools providing opportunities to educate students on health behaviors, the home has a strong impact on healthy eating and activity (Rosenkranz & Dzewaltowski, 2008). In Western countries, the majority of video game interventions have been conducted in the home setting. Home environments are

interactive domains composed of micro- and macro- level environments and are essential venues to target when considering the improvement of children's eating habits and prevention of obesity (Birch & Davison, 2001). The application of video games for health-related outcomes in Hong Kong is at a very early stage, therefore, further efforts could be directed at applying video games in the home and recreational facility settings. In addition, the Diab intervention could be replicated and disseminated to patients suffering from various chronic diseases.

Conclusion

Video game playing is now a phenomenon that is woven into fabric of children's life and has been developed to educate individuals in health-related areas. Diab is an entertaining but serious, theoretically grounded health video game with immersive storyline. The current intervention study has revealed that Diab partially motivated children to improve their motivation, self-efficacy, and preference for diet and PA behaviors immediately after completing nine episodes of the game. Health videogames with appealing characters and immersive stories have the potential to provide an innovative medium for children's behavior change. However, the lasting effectiveness and mechanisms of change of these games require more thorough investigation. The current thesis has contributed to an understanding of the health videogame in childhood obesity prevention among Hong Kong Chinese children. Finally, the current study has demonstrated the validity of the PAQ-C as well as the important effects of self-efficacy and autonomous motivation in predicting PA, which contributes to the literature informing the development of efficacious interventions for childhood obesity prevention.

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APPENDICES

Appendix A. Consent Letter

有故事線的健康視頻遊戲（Immersed Health Video Game）促進學生合理飲食、增強體力活動量、預防肥胖的研究

尊敬的學生家長：

您好！

兒童肥胖率在過去三十年間急速上升，已經成為全球公共衛生問題。2012/2013 年度香港小學生超重肥胖率高達 20.8%，每 5 名學童中即有 1 名學童為超重肥胖。而超重肥胖對學童的生理和心理健康、以及學業成績等都有很多不利的影響，有的影響甚至會延續到他們的成年期。因此，積極有效的改善飲食、提高體力活動水準、預防兒童肥胖尤為重要。

香港浸會大學體育學系將進行一項健康視頻遊戲預防肥胖的研究計劃。這個“遠離糖尿病和肥胖”的視頻由美國 Archimage 公司和 Houston 貝勒醫學院兒童肥胖專家聯合耗巨資研發，講述一個年輕人掉入敵人控制的、肥胖和糖尿病主導的惡劣環境中。此時，玩家要代替年輕人作為主人公，必須在這個惡劣環境中快速準確地選擇健康的飲食和運動方式才能夠逃離敵人的控制，回到健康的社會中。本視頻將健康知識點結合在遊戲過程中，並將很多知識點設置在需要主人公快速做出選擇的關鍵時候，否則主人公的生命將會受到威脅，遊戲結局也會因此改變。遊戲視頻共 9 個節段，前四個節段關於飲食行為，后 5 個節段關於體力活動。此視頻旨在加深學生作為主人公的意識，強化健康知識理念，並督促學生進一步做出行為改善。希望家長能予以支持,參與內容包括：

1. 在校內教師的幫助下，**組織學生在課餘時間（為時 10 周）**使用健康視頻遊戲，以增強他們的健康知識、改善學生飲食行為和體力活動水平
2. 在校內進行相關的測試，包括身高、體重
3. 填寫飲食和體力活動相關問卷
4. 問卷完成後，學生將佩戴**動作感應器**以測量準確的身體活動水準。動作感應器是一個輕型（3.5×3.3×1.4 釐米/ 重量:30 克）的設備，研究證明動作感應器是一個安全，可靠和有效的工具用以量度兒童的體力活動量，包括活

動量, 向量幅度, 能量消耗，步數及活動強度。兒童會將連接了彈性腰帶的感應器配帶於右側腰部。學童需要連續 7 天佩戴此儀器以獲得精確的體力活動水準。在遇水活動時（如洗澡、沖涼、游泳等）需要將儀器摘下。佩戴此感應器不會對學童的日常生活有任何不良影響。研究結束收回儀器後，我們會反饋給您**準確詳細的學童體力活動報告**（包括步數、體力活動等級、活動量及活動能量消耗、同班級的總體水準比較情況等），**並頒發學童參與研究的證明書**。

如果您和您的孩子決定參加這項研究，在簽署知情同意書前，您可以就任何問題諮詢我們。學童在研究過程中，有權隨時終止或退出而無任何責任，研究中所有個人資訊絕對保密，並在研究發表後即予銷毀。若有任何疑問，請與本人或本計劃助理聯絡（見背頁）。多謝您的合作，期待您的回覆。 研究助理： 王晶晶

聯絡地址： AAB927，體育學系,香港浸會大學,香港浸會大學道 15 號，九龍塘，九龍
聯絡電話：（852）3411 6405，6354 8922
敬希垂注！

研究計劃負責人
劉永松博士謹啟
香港浸會大學體育學系教授
2014 年 5 月 12 日

家長信回執

茲証明本人(家長姓名) _____ （請選擇）□同意 / □不同意子女(學生姓名）_____，年級_____班別_____學號 _____參加由香港浸會大學體育學系舉辦之應用動作感應器和問卷對學童體力活動水準和飲食行為的調查研究。

若您同意，則視為明白及同意以下項目中對於孩子的安排：

1. 我完全明白以上所述的研究內容，我的孩子願意提供項目所需要的資料。
2. 我明白項目中對孩子數據的收集及管理，任何與此計劃之個人資料均絕對保密， 計劃完畢後即予銷毀。
3. 我明白在研究過程中，有權隨時終止或退出而無任何責任。

_____ _____

家長簽署 學童簽署

_____ _____

聯繫電話 日期

請將此回條交回學校老師。多謝支持！

Appendix B. Chinese Version of Questionnaire Set

香港浸會大學健康視頻遊戲與行為的研究

學生調查問卷

親愛的同學，感謝您參加我們的關於“健康視頻遊戲與行為”的問卷調查子研究，我們需要您填寫一系列問卷來了解您平時飲食與體力活動的狀況，以及自我效能及行為動機等情況。問卷是由一些簡單的問題組成，大概需要 15-25 分鐘完成。**所有問題都只能選擇一個答案**。填寫過程中如果有看不懂的題目，可以向研究人員或老師提問。

您所填寫的答案是絕對**保密**的，不會透露給研究人員以外的其他人員。是否參與調查的結果不會影響您與學校及老師的關係。請根據您的真實情況填寫，敬請合作，謝謝！

如有疑問，可查詢：香港浸會大學體育學系，王晶晶小姐，電話：34116405。

開始填寫問卷前，請您先認真閱讀下面的說明：

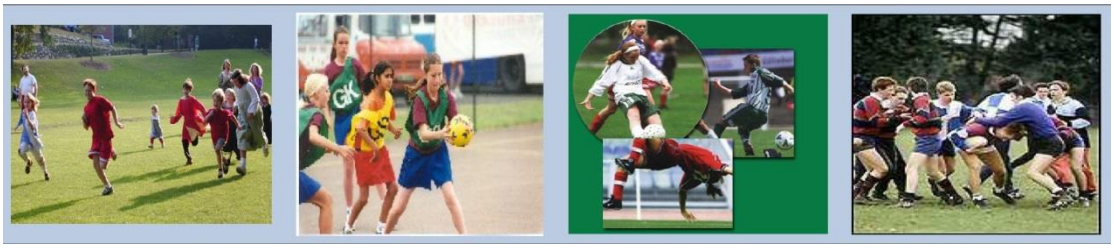
什么是體力活動?

包括參加一些有組織的體育運動，比如籃球、橄欖球、曲棍球、足球、田徑、籃球、柔道、網球等；也包括其他一些有組織的活動，比如游泳、跳舞、體操等；其他一些課外時間的活動也是體力活動，比如玩滑板、騎自行車、遛狗、跑步等。體力活動分為：

輕度體力活動：身體在活動，但是心跳和呼吸的增加並不明顯，和平時差不多。可能不會出汗，除非天氣很熱。在進行活動同時，可以很輕鬆地和別人說話交談。如寫家課、看書、看電視、慢慢散步等。

中度體力活動：活動時，心跳和呼吸有所加快。開始覺得有一點喘氣，有可能會伴有出汗並且就覺得腿有一些些累。

重度體力活動：心臟跳得很快，呼吸也很快，並且有出汗。可能“氣喘吁吁”得很厲害並且感覺到累。可能會覺得腿很沉，運動時很難開口和別人說話。



下面请您开始回答问卷：Let’s Go!

您的姓名：_____

_____年级 _____班级　　性别：□ 男　□ 女

您的年龄： _____岁（出生日期：_____年____ 月____日）

您的身高为： _____（请在正确的单位上打勾（√）：□ 厘米 / □ 英尺）

您的体重为： _____（请在正确的单位上打勾（√）：□ 千克 / □ 磅）

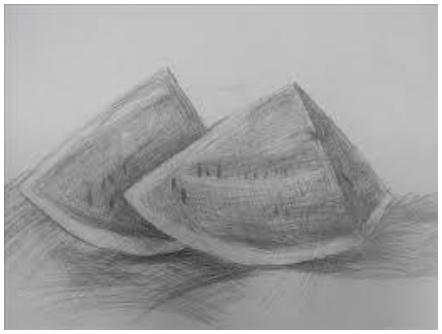
1.1 饮食喜好問卷

我們想知道您有多喜歡下面這些食物，请在最符合您喜欢程度的选项下打勾（√）

		從未吃/喝過	我不喜歡	我有點喜歡	我非常喜歡
1	香蕉	□	□	□	□
2	蘋果	□	□	□	□
3	哈密瓜或其他甜瓜	□	□	□	□
4	葡萄/提子	□	□	□	□
5	橙子	□	□	□	□
6	梨	□	□	□	□
7	李子/西梅	□	□	□	□
8	奇異果	□	□	□	□
9	草莓/士多啤梨	□	□	□	□
10	菠萝/鳳梨	□	□	□	□
11	柚子/葡萄柚	□	□	□	□
12	水果沙拉或什錦水果	□	□	□	□
13	蘋果醬	□	□	□	□
14	西瓜	□	□	□	□
15	葡萄乾/提子乾	□	□	□	□
16	水果乾/果脯	□	□	□	□
17	桃子	□	□	□	□
18	紅蘿蔔	□	□	□	□

		從來沒吃/喝過	我不喜歡	我有點喜歡	我非常喜歡
19	芹菜	☐	☐	☐	☐
20	甘藍/芥蘭	☐	☐	☐	☐
21	菠菜	☐	☐	☐	☐
22	炸薯條	☐	☐	☐	☐
23	馬玲薯(薯仔) 沙律	☐	☐	☐	☐
24	其他馬玲薯製品	☐	☐	☐	☐
25	粟米	☐	☐	☐	☐
26	綠豆	☐	☐	☐	☐
27	番茄/番茄	☐	☐	☐	☐
28	西蘭花	☐	☐	☐	☐
29	萵苣/生菜	☐	☐	☐	☐
30	四季豆/青豆	☐	☐	☐	☐
31	菜絲沙拉	☐	☐	☐	☐
32	扁豆，豇豆，花豆	☐	☐	☐	☐
33	番薯	☐	☐	☐	☐
34	小白菜/捲心菜	☐	☐	☐	☐
35	洋蔥	☐	☐	☐	☐
36	100%純果汁	☐	☐	☐	☐
37	純淨水	☐	☐	☐	☐





1.2 體力活動喜好問卷

告訴我們您有多喜歡下面的這些運動，請在最符合您的選項上打勾（√）

		我從未做過	不喜歡	有點喜歡	非常喜歡
1	踩單車	□	□	□	□
2	游泳	□	□	□	□
3	體操	□	□	□	□
4	俯臥撐、仰臥起坐或者跳躍類的運動	□	□	□	□
5	籃球	□	□	□	□
6	棒球或者壘球	□	□	□	□
7	橄欖球	□	□	□	□
8	足球	□	□	□	□
9	排球	□	□	□	□
10	羽毛球，網球類等板球運動	□	□	□	□
11	划船	□	□	□	□
12	追逐、捉人等遊戲	□	□	□	□
13	爬樹，捉迷藏等戶外遊戲	□	□	□	□
14	水上活動（在游泳池，海裏或者湖裏玩耍）	□	□	□	□
15	跳繩	□	□	□	□
16	跳舞	□	□	□	□
17	除草、挖地、做園藝等室外家務活	□	□	□	□
18	拖地、吸塵或者打掃衛生等室內家務活	□	□	□	□
19	散步	□	□	□	□
20	跑步或者慢跑	□	□	□	□
21	溜冰、輪滑或者溜旱冰	□	□	□	□
22	空手道，柔道、跆拳道或者其他武術	□	□	□	□
23	學校的體育課	□	□	□	□
24	在遊樂場內攀爬遊樂器材等	□	□	□	□
25	遠足/行山	□	□	□	□
26	舉重或力量訓練	□	□	□	□
27	瑜伽	□	□	□	□
28	啦啦隊或操練隊	□	□	□	□

2. 飲食和體力活動動機問卷

請選擇下面各項是不是您吃水果、蔬菜、喝水（不包括飲料）和做體力活動的原因。

我常吃水果的原因有……		**否**	**不確定**	**是**
1	我希望其他人認為我很酷/帥/靚	☐	☐	☐
2	我希望自己和朋友們不一樣	☐	☐	☐
3	其他人讓我這麼做	☐	☐	☐
4	如果不吃水果的話，我會受到懲罰	☐	☐	☐
5	如果吃糖而不是吃水果的話，我會感到內疚	☐	☐	☐
6	如果不吃水果的話，我會自我感覺不好	☐	☐	☐
7	吃水果對我很重要	☐	☐	☐
8	吃水果讓我感到開心	☐	☐	☐
9	我想要好好照顧自己	☐	☐	☐
10	我想要吃東西，但不吃沒營養的食品	☐	☐	☐
11	吃水果很有樂趣	☐	☐	☐
12	我很享受吃水果	☐	☐	☐

我常吃蔬菜的原因是……		**否**	**不確定**	**是**
1	我希望別人覺得我很酷/帥/靚	☐	☐	☐
2	我希望自己和朋友們不一樣	☐	☐	☐
3	如果不吃蔬菜的話，我會被懲罰	☐	☐	☐
4	我覺得我必須要吃	☐	☐	☐
5	如果我不吃蔬菜的話，我會自我感覺很差	☐	☐	☐
6	我希望別人認為我是個健康飲食的人	☐	☐	☐
7	吃蔬菜對我來說很重要	☐	☐	☐
8	我想要照顧好自己	☐	☐	☐
9	吃蔬菜很有樂趣	☐	☐	☐

我常飲水（不包括飲料）的原因是……		否	不確定	是
1	飲水有利於自己的身體健康	☐	☐	☐
2	我想要照顧好自己	☐	☐	☐
3	飲水對我來說很重要	☐	☐	☐
4	我想要飲除了甜品以外的飲品	☐	☐	☐
5	飲水讓我很快樂	☐	☐	☐
6	我想讓別人知道我喝飲料。	☐	☐	☐
7	如果不飲水的話，我會自我感覺不好	☐	☐	☐
8	其他人讓我飲水	☐	☐	☐
9	如果不飲水的話，我會受到懲罰	☐	☐	☐

3. 自我效能問卷

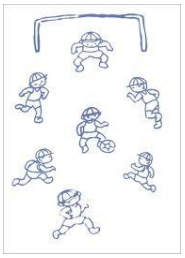
您是否確定您能夠做到以下列出的各個條目？請選擇：

水果：您有多大把握自己能夠做到		**不確定**	**有點確定**	**非常確定**
1	每週要求家人為我買我喜歡的水果或者蔬菜?	☐	☐	☐
2	最少有一次要求家人購買三件/個水果或者蔬菜?	☐	☐	☐
3	每週要求家人最少購買三件/個水果或者蔬菜?	☐	☐	☐
4	最少 1 次在學校午餐時吃 1 份水果？	☐	☐	☐
5	不上學（包括週末）的日子裏，最少一次午餐吃一份水果?	☐	☐	☐
6	大多數的不上學日（包括週末）的午餐中，吃一份水果?	☐	☐	☐
7	最少一次在家吃 1 份水果作為小食?	☐	☐	☐
8	每週最少 4 日在家吃 1 份水果作為小食?	☐	☐	☐
9	在家裏吃晚餐時，大多數晚上要求家人提供一份水果代替通常的餐後甜點?	☐	☐	☐
10	最少 1 次在家吃 1 份水果作為晚餐？	☐	☐	☐
11	最少 1 次在快餐店吃 1 份水果？	☐	☐	☐
12	在速食店吃飯時，大多數時候都會吃一份水果?	☐	☐	☐

蔬菜：你有多大把握你能做到		**不確定**	**有點確定**	**非常確定**
1	最少 1 次在上課日的午餐里吃一份蔬菜?	☐	☐	☐
2	最少有一次切一份蔬菜並沾料當作小食?	☐	☐	☐
3	最少有一次要求家人為晚餐準備 2 份蔬菜?	☐	☐	☐
4	大多數時候要求家人為晚餐準備 2 份蔬菜?	☐	☐	☐
5	一周裏最少有四天，每天吃 3 份蔬菜?	☐	☐	☐
6	當我有壓力時，一周裏最少有四天，每天吃 3 份蔬菜?	☐	☐	☐
7	在快餐店用餐時，大多數時候都會吃一份蔬菜?	☐	☐	☐
8	在餐廳用餐時，大多數時候都會吃一份蔬菜?	☐	☐	☐

喝水：你有多大把握你能做到		不確定	有點確定	非常確定
1	最少有一天，在口渴的時候只飲水？	☐	☐	☐
2	最少有一天，飲 4 杯/瓶水？	☐	☐	☐
3	每週裏最少有 4 天，口渴的時候只飲水？	☐	☐	☐
4	每週裏最少有 4 天，每天飲 6 杯/瓶的水？	☐	☐	☐
5	最少有一天飲 6 杯/瓶水？	☐	☐	☐

體力活動：你有多確定你有/你能		不確定	有點確定	非常確定
1	能夠進行跑步，跳舞，踏單車或者跳繩等體力活動？	☐	☐	☐
2	非常擅長跑步，跳舞，踏單車或者跳繩等體力活動？	☐	☐	☐
3	能夠參與打籃球，踢足球或壘球等團體活動？	☐	☐	☐
4	非常擅長打籃球，踢足球或壘球等團體活動？	☐	☐	☐
5	最少有一天，能夠邀請朋友們一起，做 30 分鐘以上的體力活動？	☐	☐	☐
6	一周裏最少有 4 天，能邀請朋友們一起，做 30 分鐘以上的體力活動？	☐	☐	☐
7	即使有功課要寫，也能一天做 30 分鐘以上的體力活動？	☐	☐	☐
8	即使有很多事情要做，也能一天做 30 分鐘以上的體力活動？	☐	☐	☐
9	即使有很多事情要做，一周裏也最少有 4 天，能做 30 分鐘以上的體力活動？	☐	☐	☐
10	當我的朋友們想做其它的事情時，也能在一周內最少有 4 天，做 30 分鐘以上的體力活動？	☐	☐	☐
11	即使室外天氣很差，也能每週最少有 4 天，做 30 分鐘以上的體力活動？	☐	☐	☐
12	在大多數不上學的日子（包括週末），做 30 分鐘以上的體力活動？	☐	☐	☐



4. 小學生體力活動問卷

我們想瞭解在過去的 **7 天時間裏**您的體力活動情況。包括您做運動、跳舞、或者那些讓您雙腿感到累、或者讓您呼吸有困難等的活動，像跑步、爬山、跳繩等。

1. **課外參與體力活動狀況**：在過去的7天裏，您是否做過以下體育活動？如果沒有做過，請選擇‘沒有’；如果有，請選擇做過的次數。（**每題只選一個答案**）

		沒有做	1-2次	3-4次	5-6次	7次或以上
1	跳繩	☐	☐	☐	☐	☐
2	划船	☐	☐	☐	☐	☐
3	輪滑或者溜冰	☐	☐	☐	☐	☐
4	捉迷藏	☐	☐	☐	☐	☐
5	步行鍛鍊	☐	☐	☐	☐	☐
6	踏單車	☐	☐	☐	☐	☐
7	慢跑或跑步	☐	☐	☐	☐	☐
8	健身操	☐	☐	☐	☐	☐
9	游泳	☐	☐	☐	☐	☐
10	棒球、壘球等	☐	☐	☐	☐	☐
11	跳舞	☐	☐	☐	☐	☐
12	壁球	☐	☐	☐	☐	☐
13	羽毛球	☐	☐	☐	☐	☐
14	滑板運動	☐	☐	☐	☐	☐
15	足球/橄欖球	☐	☐	☐	☐	☐
16	曲棍球	☐	☐	☐	☐	☐
17	排球	☐	☐	☐	☐	☐
18	網球	☐	☐	☐	☐	☐
19	籃球	☐	☐	☐	☐	☐
20	乒乓球	☐	☐	☐	☐	☐
21	遠足/行山	☐	☐	☐	☐	☐
22	武術（如跆拳道、柔道等）	☐	☐	☐	☐	☐
23	其他 1（請補充）： _____	☐	☐	☐	☐	☐
24	其他 2（請補充）： _____	☐	☐	☐	☐	☐

2. 在過去一個星期的**體育課裏**，您有多少時候會很活躍？（如進行劇烈活動、奔跑、跳躍、投擲等動作）（只選**一個**答案）

我不參與體育活動	非常少	間中	稍多	很經常
☐	☐	☐	☐	☐

3. 在過去一個星期的**小息時間裏**，您通常在做甚麼？（只選**一個**答案）

坐著（談話、閱讀或做家課）	☐
站著或散步	☐
少許運動或追逐	☐
稍多運動及追逐	☐
經常及劇烈地運動及追逐	☐

4. 在過去一個星期的**午膳時間（除了用餐時間外）**，您通常在做甚麼？（只選**一個**答案）

坐著（談話、閱讀或做家課）	☐
站著或散步	☐
少許運動或追逐	☐
稍多運動及追逐	☐
經常及劇烈地運動及追逐	☐

5. 以下**哪一句**最能形容您過去7天參與體力活動的情況？請請閱讀所有選項后，選出**一個**答案：

a) 我上星期全部空餘時間所進行的活動只需少許體力	☐
b) 在上星期的空餘時間裏，我間中（1-2 次）進行體力活動（例如跑步、游泳、踏單車等）	☐
c) 在上星期的空餘時間裏，我常（3-4 次）進行體力活動（例如跑步、游泳、踏單車等）	☐
d) 在上星期的空餘時間裏，我經常（5-6 次）進行體力活動（例如跑步、游泳、踏單車等）	☐
e) 在上星期的空餘時間裏，我十分多地（7 次或以上）進行體力活動（例如跑步、游泳、踏單車等）	☐

6. 在過去一個星期，有多少天的**課外時間**您會參與體育、舞蹈、或遊戲等體力活動？

無	1 天	2-3 天	4 天	5 天
☐	☐	☐	☐	☐

7. 在過去一個星期，有多少天**晚上**您會參與體育、舞蹈、或遊戲等體力活動？

無	1 天	2-3 天	4 天	5 天
☐	☐	☐	☐	☐

8. 在**上個週末**，您會進行體育、舞蹈或遊戲等體力活動多少次？

無	1 次	2-3 次	4-5 次	6 次或以上
☐	☐	☐	☐	☐

9. 在上個星期的每一天裏，您進行體育活動、遊戲、舞蹈等**體力活動**的情況是：（每天只能選一個答案）：

	沒有做任何	做少許	做中等量	做得較多	做非常多
Monday 星期一	☐	☐	☐	☐	☐
Tuesday 星期二	☐	☐	☐	☐	☐
Wednesday 星期三	☐	☐	☐	☐	☐
Thursday 星期四	☐	☐	☐	☐	☐
Friday 星期五	☐	☐	☐	☐	☐
Saturday 星期六	☐	☐	☐	☐	☐
Sunday 星期日	☐	☐	☐	☐	☐

10. 您上個星期裏有沒有生病、或有甚麼事情妨礙您不能從事正常的體育活動？

☐ 沒有

☐ 有，因為（請填寫）_____

5. 社會期許問卷

請仔細閱讀下面的描述，選擇最符合您的選項：

		我總是這樣	我有時這樣	不確定	我完全不這樣
1	我喜歡每一個我認識的人	☐	☐	☐	☐
2	我一直是個和善的人	☐	☐	☐	☐
3	我總是很有禮貌	☐	☐	☐	☐
4	我一直是個好人	☐	☐	☐	☐
5	我總是很友善地對待所有人	☐	☐	☐	☐
6	我每次都說真話	☐	☐	☐	☐
7	我從不會生氣	☐	☐	☐	☐
8	我從不說不應該說的話	☐	☐	☐	☐
9	我從不撒謊	☐	☐	☐	☐

6. 遊戲沉浸度問卷

在玩完電子遊戲「逃離肥胖和糖尿病」後（下稱「遊戲」），請選擇下列條目中描述最適合你的答案。

		不同意	部分同意	非常同意
1	‘遠離肥胖’遊戲中的人物角色看起來很真實。	☐	☐	☐
2	我可以很容易回想起遊戲裏所發生的事情。	☐	☐	☐
3	當我正在玩遊戲時，我注意不到身邊發生的事情。	☐	☐	☐
4	我感覺到自己是遊戲中的一部分。	☐	☐	☐
5	我覺得‘遠離肥胖’遊戲裏面發生的事情在現實中也在發生。	☐	☐	☐
6	我發現我在玩遊戲時會走神、心不在焉。	☐	☐	☐
7	我迫不及待想看遊戲的結局。	☐	☐	☐
8	當‘遠離肥胖’遊戲中的人物遇到不好的事情時，我會覺得難過。	☐	☐	☐
9	當‘遠離肥胖’遊戲中的人物遇到高興的事情時，我會覺得開心或者興奮。	☐	☐	☐
10	當‘遠離肥胖’遊戲一個章節結束時，我不能停止去想著它。	☐	☐	☐
11	當‘遠離肥胖’遊戲結束時，我會考慮會不會有其他不同的結局。	☐	☐	☐
12	在結束 ‘遠離肥胖’遊戲後，我很快就把它忘了。	☐	☐	☐
13	我從‘遠離肥胖’遊戲中學到了有用的事物。	☐	☐	☐
14	‘遠離肥胖’遊戲結束後，我感覺遊戲中至少有一個人物角色讓我覺得像個朋友一樣。	☐	☐	☐
15	至少有一個‘遠離肥胖’遊戲裏的人物角色讓我想到我自己。	☐	☐	☐
16	至少有一個‘遠離肥胖’遊戲裏的人物角色讓我想到我的朋友們	☐	☐	☐
17	當‘遠離肥胖’遊戲裏的人物角色面臨挑戰時，我想幫助他們。	☐	☐	☐
18	玩‘遠離肥胖’這個遊戲改變了我的生活。	☐	☐	☐

7. 體力活動動機問卷

人們進行規律運動的原因有許多。請仔細閱讀下列題目，確定題目描述的內容跟您的實際情況相符合的程度，**1 表示完全不符合您**，然後符合的程度逐漸增加，**7 為非常符合您**。請把做最符合您實際情況的數字寫在題目後面的橫線上。

1 2 3 4 5 6 7

完全不符合我 部分符合我 非常符合我

1. 因為如果我不運動，我覺得自己很不舒服。 1._____
2. 因為如果我不運動，其他人會對我生氣。 2._____
3. 因為我享受做運動。 3._____
4. 因為如果我不運動，我感覺自己像個失敗者。 4._____
5. 因為我覺得運動是幫助自己保持健康的最好辦法。 5._____
6. 因為如果我不運動，別人會認為我很弱。 6._____
7. 因為我覺得我沒有其他的選擇，別人要求我做運動。 7._____
8. 因為對完成我的目標來說，運動是一個挑戰。 8._____
9. 因為我相信做運動能讓我感覺更好。 9._____
10. 因為運動很有趣。 10._____
11. 因為我擔心如果我不運動，我就會與別人有麻煩。 11._____
12. 因為對我個人而言，完成這個目標很重要。 12._____
13. 因為如果不運動的話，我會感到內疚。 13._____
14. 因為我想讓別人注意到，我正在做我應該做的事。 14._____
15. 因為看到自己的進步是很有趣的事。 15._____
16. 因為感覺身體更健康對我來說很重要。 16._____

Appendix C. Wearing Log for ActiGraph

動作感應器佩戴說明及佩戴日誌

尊敬的學生及家長，您好！

為了解您孩子每天的體力活動水平及消耗的能量，我們將給您的孩子**免費**佩戴體力活動測量儀，此儀器不會對您孩子的身體和學習造成任何不良影響。在此期間，請您和您的孩子配合我們做好以下幾件事：

1) 儀器需要垂直佩帶在您孩子的腰間，在腰部的**右前方**，不能在正中位置。仪器需要**连续佩戴7天**。

2) 請您的孩子在每天**早晨起床後立刻佩帶**，一直到**晚上上床睡覺時摘下**，晚上睡覺時可將儀器放在桌子上，儀器會繼續記錄靜態消耗量；

3) 儀器為電子產品需要防火、防水、防摔、防撞，避免碰撞硬的物品或摔在地上，**不要在洗澡、游泳**等遇水情況下佩戴，否則儀器將會因進水導致損壞。

動作感應器佩戴在身體右側，如圖所示的位置。佩戴時，上面的字母應該是正立的。請自行調整腰帶的長度，非常重要的一點是要保證動作感應器緊貼身體（不需緊貼皮膚）。如果它松松地佩戴上，將不能準確進行測量。

我們建議学生能夠連續七日佩戴，以便提供完整的資料可以分析日常體力活動量。但是如果由於任何原因，**某一日您未能戴滿整日，請記得在隨後的日子繼續佩戴。**結束所有的測量後，我們會提供一份報告說明您的資料，並給出一定的健康建議。如果不能提供完整的資料，分析將不夠完整準確。

統一收回動作感應器的時間是 **12 月 5 日（週五），請將儀器帶到學校交至老師。**

如果動作感應器（約 HK$3000）有損壞或丟失，參加者不需賠償，我們懇切希望家長協助參加者妥善保管，參加者需自己佩戴，不可以借給他人。如果您有任何疑問，請與研究助理聯繫（聯繫人：王晶晶小姐，聯繫電話：3411 6405, 6354 8922），謝謝您的配合。

------請完成背面的日記記錄------

動作感應器佩戴日誌

姓名：_____ 班別：_____

請寫下佩戴動作感應器的日期，每天早上幾時佩戴動作感應器，以及睡前除下動作感應器的時間。

如果有時在一天中，你由於某些原因（比如沖涼，游泳）除下動作感應器，請寫下你什麼時候除下以及什麼時候重新佩戴，並記錄原因。

日期	早上佩戴	夜晚除下	日中除下	重新佩戴	除下動作感應器的原因
例如 第一日：11 月 01 日	*7.30 am*	*8.20pm*	*12.45pm*	*2.15pm*	*游泳*
第一日：11 月 28 日					
第二日：11 月 29 日					
第三日：11 月 30 日					
第四日：12 月 1 日					
第五日：12 月 2 日					
第六日：12 月 3 日					
第七日：12 月 4 日					
補戴日：12 月 日 **（如需繼續佩戴）**					
補戴日：12 月 日 **（如需繼續佩戴）**					

請將佩戴日誌和動作感應器在完成指定天數之後，12 月 5 日（週五）交還至老師，

非常感謝您參與我們的研究。

CURRICULUM VITAE

Academic qualifications of the thesis author, MS. WANG Jing Jing:

- Received the degree of Bachelor of Medicine in Preventive Medicine in School of Public Health from Shandong University, Shandong, China, July 2008.
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