Title: Measuring perceived exercise capability and investigating its relationship with childhood obesity: A feasibility study

Running head: EXERCISE CAPABILITY AND CHILDHOOD OBESITY FEASIBILITY

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Abstract

Background/Objectives: According to the COM-B model of behaviour, three factors are essential for behaviour to occur: capability, opportunity and motivation. Obese children are less likely to feel capable of exercising. The implementation of a new methodological approach to investigating the relationship between perceived exercise capability (PEC) and childhood obesity was conducted, which involved creating a new instrument, and demonstrating how it can be used to measure obesity intervention outcomes.

Subjects/Methods: A questionnaire aiming to measure perceived exercise capability, opportunity and motivation was systematically constructed using the COM-B model and administered to Seventy-one obese children (aged 9-17 [12.24±.2.01], BMI SDS 2.80±.660) at a weight-management camp in northern England. Scale validity and reliability was assessed. Relationships between PEC, as measured by the questionnaire, and BMI SDS were investigated for the children at the weight-management camp, and for 45 Spanish schoolchildren (aged 9-13, [10.52±1.23], BMI SDS 0.80±.99). A pilot study, demonstrating how the questionnaire can be used to measure the effectiveness of an intervention aiming to bring about improved PEC for weight-management camp attendees, was conducted. No participants withdrew from these studies.

Results: The questionnaire domain (exercise capability, opportunity and motivation) composite scales were found to have adequate internal consistency (a = .712-.796) and construct validity (X^2/DF = 1.55, RMSEA = .072, CFI = .92). Linear regression revealed that low PEC was associated with higher baseline BMI SDS for both UK (b = -.289, p = 0.010) and Spanish (b = -.446, p = 0.047) participants. Pilot study findings provide preliminary evidence for PEC improvements through intervention being achievable, and measurable using the questionnaire.

Conclusions: Evidence is presented for reliability and validity of the questionnaire, and for feasibility of its use in the context of a childhood obesity intervention. Future research could investigate the link between PEC and childhood obesity further.

Keywords: Pediatric Obesity; Weight loss; Exercise

Introduction

Physical inactivity is associated with childhood obesity(1); there is evidence that this is partly due to obese children perceiving themselves as being incapable of exercise(2). Physical activity interventions have been found to be effective in aiding short-term weight-loss(3), though evidence of their ability to bring about weight-loss in the longer term has been equivocal(4-7); a greater evidence base for informing effective intervention design is needed. The work described here presents a theory-driven method for measuring perceived exercise capability (PEC). Interventions that lead to improvements in PEC of obese children may lead to greater levels of exercise being conducted, and greater weight-loss being achieved by this sample. We constructed and tested the validity and reliability of an instrument that aims to measure PEC, which could be used in such interventions. A study demonstrating how the instrument can be used to measure obesity intervention effectiveness is also described.

Our method for measuring PEC was informed by the COM-B model(8, 9), which is based upon systematic, overarching study of behaviour change evidence and posits that there are 3 types of influences upon behaviour: ‘Capability’, referring to an individual’s physical or psychological capability to perform the behaviour in question; ‘Opportunity’, which accounts for all the factors outside of the individual that prompt, or make possible the behaviour and ‘Motivation’, referring to all the brain processes that energise and direct behaviour. Behaviour change is achieved by altering the intervention recipients’ ‘capability’, ‘opportunity’, ‘motivation’, or a combination of these factors, causing them to become more likely to carry out the behaviour. All 3 factors are essential for a behaviour, such as physical exercise, to occur; we predicted that capability would be the most important factor in encouraging exercise for obese children because low perceived exercise capability has been linked to less active lifestyles for children in general(10, 11) and obese children in particular(2). Without enabling PEC, exercise behaviours will not occur, regardless of motivation or opportunity levels(8, 9). PEC and obesity are likely to influence each other: Failing to exercise due to feeling incapable would increase risk of weight gain; being obese and having a different body shape to the kind usually associated with sport and athletics would be likely to result in reduced PEC. Being able to accurately measure obese children's PEC would help to inform interventions designed to improve PEC through enablement(9). Such interventions could bring about long-term benefits in weight-management. The COM-B framework has been used to design many different types of behavioural interventions(9), but the relative importance of the elements of the framework in predicting exercise behaviours for obese children is not known.

Study 1 describes the construction of a questionnaire, based on the COM-B model, which aimed to measure perceived exercise capability, opportunity and motivation. The questionnaire underwent several stages of reliability and validity testing including variability of response, skew, internal consistency within the three domains (capability opportunity and motivation), and construct validity. The predictive value of the questionnaire domains upon child respondents' BMI SDS was investigated with the prediction that PEC would be inversely associated with BMI SDS. A pilot study (Study 2), demonstrating how the questionnaire can be used to measure the effectiveness of an intervention aiming to bring about improved PEC for obese children, was also conducted.

Study 1: Questionnaire construction, tests of validity and reliability, and investigation of relationships between questionnaire variables and BMI SDS in children

Methods

Two groups of participants were recruited: One from England, One from Spain; ethical approval was granted by the Imperial College Research Ethics Committee and the Ethics Committee for Clinical Research of La Rioja. Informed consent was obtained from participants and, as all were under 18 years of age, consent for their participation was also obtained from their parents or guardians. Participants' height and weight were measured using a calibrated scale and wall-mounted stadiometer; these measurements were used to calculate BMI SDS.

The English group consisted of 71 children (34 female) aged 9-17 years (12.24±1.96) who attended a weight-management summer camp in Northern England for between 1 and 6 weeks (2.66±1.33), depending on the length of times for which their families had planned for them to stay. All camp attendees were eligible to participate in the study. On arrival at the camp, participants' World Health Organisation (WHO) Body Mass Index (BMI) Standard Deviation Scores (SDS) ranged from 1 to 4 (2.80±.65) and the mean BMI SDS reduction over their time at the camp was .251±.154 reflecting statistically significant weight-loss across the group ($Z(71) = -7.375$, $p < .001$). The residential camp provided physical exercise activities such as team sports games and group fitness sessions, lifestyle education, counselling and controlled food portions.

An additional sample of 45 children (22 female, aged 9-13 [10.52±1.23], WHO BMI SDS ranging from -1 to 3 [.80±.99]) were recruited from schools in northern Spain. We analysed data collected from this sample to ensure generalizability of findings from UK participant data.

Construction of the COM-B exercise attitudes questionnaire. A questionnaire that aimed to measure perceived exercise capability, opportunity and motivation was constructed systematically using the COM-B framework(8). To ensure that the items represented a broad range of factors affecting behaviour, the MINDSPACE framework, which describes the 9 categories of influences upon human behaviour(12) (See Table 1) and can be applied within the COM-B model, was also used to inform questionnaire item construction.

'Capability' can be subdivided into psychological and physical capability, ‘opportunity’ can be subdivided into social or physical opportunity and ‘motivation’ can be subdivided into automatic and reflective processes(9). We ensured that each of these subdivisions was represented by at least one item (see Table 2). All but one of the MINDSPACE dimensions were represented by at least one item: ‘Priming’ did not inform an item because a child would usually not be aware of this factor affecting their behaviour. Systematically using MINDSPACE and COM-B, and considering the aspects of a child’s life that might influence the extent to which they exercise, we attempted to create a set of questions that was not overly long, but that was thoroughly assessed possible behavioural influences relevant to exercise.

Care was taken to phrase the wording of the items clearly, and in a way that would be understandable to children as young as seven years. Each item was expressed as a statement, with respondents reporting the extent to which they agreed with it on a 1-7 scale (1 = ‘strongly disagree’; 7 = ‘strongly agree’). Responses to the items were used to construct composite Capability, Opportunity and Motivation scales for each participant. This was done by calculating the mean response scores of items in each of the three domains (See Table 2), after responses to items “Thinking about exercise reminds me of bad times that I have had” and “Exercising can make me feel sad” had been reversed.

Procedure. UK participants completed the COM-B questionnaire (See Supplementary Document 1) upon arrival at the camp. Results were used to check internal consistency of composite scales and variability of response. Relationships between BMI SDS and Capability, Opportunity and Motivation were also investigated. The questionnaire was translated to Spanish (see Supplementary Document 2), and this was completed by Spanish schoolchildren to test the generalizability of relationships indicated in UK sample. Construct validity was also investigated and skew were assessed across the two samples.

Analytic strategy. Cronbach's alpha tests of internal consistency were used to measure composite scale reliability for the three domains, and linear regression tests were used to investigate relationships between BMI SDS and perceived exercise capability, opportunity and motivation. Confirmatory factor analysis (CFA) was used to test construct validity. CFA was conducted using AMOS 22.0; all other statistical tests described in this manuscript were conducted using IBM SPSS 22.0.

Table 1

Description of the nine MINDSPACE dimensions

Dimension	Description
Messenger (M)	We are influenced by who communicates information to us
Incentives (I)	We are more likely to behave in ways that get rewarded
Norms (N)	We are influenced by the behaviour of those around us
Defaults (D)	We usually 'go with the flow', or choose the default option
Salience (S)	We pay attention to novel stimuli
Priming (P)	We are influenced by sub-conscious cues
Affect (A)	We are influenced by emotional associations
Commitments (C)	We tend to be consistent with our public promises
Ego (E)	We are motivated to feel better about ourselves

Table 2: The COM-B model being used to identify relevant attitudes relating to physical exercise behaviours

COM-B Model component	Function of the component	The statements, used as questionnaire, followed by a letter representing the relevant MINDSPACE

		dimension if applicable
Capability - The individual's psychological and physical capacity to engage in the behaviour	Psychological	• I know how much exercise I should do to stay healthy
	Physical	• I am able to do physical exercise • I am able to exercise how I would like to
	Psychological or physical	• I find it easy to do physical exercise
Opportunity - Factors, social and physical, outside of the individual that make possible or prompt the behaviour	Social	• I Understand most advice I receive about health and fitness (M) • Most of the people I know do exercise often (N)
	Physical	• There are many places where I can exercise at home and at school
	Social or Physical	• I exercise often without having to try (D) • I like to exercise in new ways (such as by playing new games or sports, or using new exercise equipment that I haven't tried before) way (S).
Motivation - The brain processes that energize and direct behaviour	Automatic - these relate to processes that do not require conscious thought	• There are many benefits to doing exercise for me (I) • Most of the time, I feel that I really want to exercise (I) • I feel good about myself when I exercise (E)

	• Thinking about exercise reminds me of bad times that I have had (E) • Thinking about exercise reminds me of good times that I have had (E) • Exercising can make me feel sad (A) • Exercising can make me feel happy (A)
Reflective - these relate to processes that require conscious thought	• I have exercise goals that I want to achieve (C) • I have a plan for how much exercise to do (C) • I would be willing to make a plan of how much exercise to do every week (C)

Results

The questionnaire composite scores were found to have adequate internal consistency. Composite PEC, exercise opportunity and exercise motivation scales were found to have Chronbach's Alpha scores of .786, .712 and .796 respectively, indicating adequate internal consistency(13). The lowest standard deviation for the response score of any item was 1.3, and all of the remaining items had standard deviations greater than 1.5. This variability was considered acceptable due to the small response scales of 1-7(14).

PEC was inversely associated with BMI SDS. A Linear regression model controlling for age revealed participants' initial Capability scores to be a significant predictor of baseline BMI SDS for both UK (b = -.289, t(68) = -2.657, p = 0.010) and Spanish participants (b = -.446, t(42) = -2.045, p = 0.047), with those with lower PEC having higher BMI SDS. No such relationship was found in either the UK sample between BMI SDS and Opportunity (b =

-.131, $t(68) = -1.167$, $p = 0.247$) or Motivation ($b = -.028$, $t(62) = -.249$, $p = 0.804$) scores, or in the Spanish sample (Opportunity: $b = .102$, t(42) = .671 , $p = 0.506$; Motivation: $b = -.156$, $t(42) = -1.040$, $p = 0.304$).

The questionnaire was found to have adequate construct validity. Confirmatory factor analysis (CFA) was performed to test whether the data from the questionnaire items collected from the UK and Spanish participants fitted within the domains (Capability, Opportunity and Motivation) to which they had been allocated. Variables with a skew greater 3 or a kurtosis index greater 10 would have been a concern(15), but these values were not exceeded for any of the items. Goodness of fit was tested using 3 indices to measure absolute fit, parsimony of fit and comparative fit(16). Acceptable absolute fit is indicated by a X2/DF ratio less than 2.0(14, 17). Acceptable parsimony of fit requires a Root Mean Square Error (RMSE) close to, or below .06 for good fit(16, 18), and below .08 for acceptable fit(18, 19). Acceptable comparative fit is indicated by a comparative fit index (CFI) above .9(16). The present model was found to have a X2/DF ratio of 1.55 ($p < .05$), an RMSE of .072 and a CFI of .92, indicating adequate construct validity.

Study 2: Pilot study to illustrate how the COM-B exercise attitudes questionnaire can be used as part of an obesity-related intervention

A small-scale intervention, designed to improve PEC and weight loss for obese children was carried out to demonstrate how the questionnaire can be used to measure obesity-related intervention effectiveness.

The intervention carried out in the present study involved obese child participants using video games that require the player to move. Such games have been demonstrated to have potential to encourage exercise behaviours for both adults and children(20). Motion-sensor computer games involve players progressing through the game by conducting movements which are detected by a motion-sensor(21). We expected that by taking part in this unconventional form of exercise, obese children, who are less likely to see themselves as people capable of exercise(2), would be more likely to change their beliefs and perceive themselves as being more capable of exercise. We provided motion-sensor computer games to groups of children at the UK weight-management camp and predicted that those who enjoyed using the games would demonstrate increases in PEC. Follow-up BMI SDS data were collected after the camp had finished from a subset of participants. We predicted that these participants' COM-B questionnaire scale results would predict their long-term weight management success. Consistency of COM-B questionnaire responses between those collected on arrival at the start of the weight-management camp and those collected on departure was measured as a preliminary investigation of test-retest reliability.

Methods

Participants. Participants were from the UK sample described in the Study 1 Methods section. Fifty of these participants (21 female, age 12.16±1.98) also used the games.

Materials. The motion-sensor games used were versions of games that at the time of writing this article were available on a website called WebCam Mania (http://mika.tanninen.net/webcam/(22)). The games were accessed from a website, using a desktop computer connected to a webcam. The webcam acted as the motion-sensor. Five similar computer games were provided; all involved the player seeing a reflection of his/herself on the screen through the webcam, and moving around to interact with other on-screen objects (for example, the goal of one game was to catch all the green moving objects while avoiding the red). In each session when the games were played, all children played the same game and all started at the easiest level. Players achieved higher scores if they conducted the required movements faster. Players who achieved sufficiently high scores were able to advance to more difficult levels of the game, which demanded slightly more physical exertion.

Procedure. The motion-sensor games were played by children on one day per week for periods of 15 minutes on weeks 1, 2, 3, 4, and 6 of the 6-week long camp (camp attendees were away on a camping trip on the 5th week on the day that they would have usually played the games). To validate the games as a form of exercise, participants' pulses were measured before playing the games, and also immediately after playing levels of the games (which each lasted about 2 minutes) using pulse oximeters. Each participants' mean heart-rate measurement, of those measured after they played the games, was used as a single outcome variable to compare to their resting heart-rate. Participants reported the extent to which they enjoyed playing the motion-sensor games on a 1-7 scale.

Twenty-eight participants completed the COM-B questionnaire on leaving, as well as arriving, at the camp (see Supplementary Table 1); twenty-two also reported the extent of their enjoyment of the motion-sensor games; and thirteen opted to take part in a further follow-up stage of the study. BMI SDS measures were taken from this group three (n = 5) or six (n = 5) months post-camp, or both (n = 3: The independent variable for these participants was the mean post-camp follow-up BMI SDS).

Analytic strategy. Linear regression tests were used to investigate relationships between BMI SDS and perceived exercise capability, opportunity and motivation. Wilcoxen Signed Rank tests were used to investigate whether then games resulted in increased heart rates, and changes in composite Capability, Opportunity and Motivation scores collected at the start and at the end of the camp. Spearman's correlations were used to investigate consistency of questionnaire responses collected on arrival to, and on departure from, the camp.

Results

Those who enjoyed the motion-sensor games showed increases in PEC. Using the games caused significant increases in participants' heart-rates ($Z(50) = -3.79$, $p < 0.001$ [mean increase: 11.51±19.09bpm]). A significant correlation was revealed between reported enjoyment of the games, and increase in Capability scores during the UK camp ($r(22) = .538$, $p = 0.010$). No correlation was found between enjoyment of the games and Motivation ($r(19) = -.144$, $p = 0.643$) or Opportunity ($r(22) = .199$, $p = 0.374$) improvement. Additionally a linear regression that controlled for initial Capability score revealed game enjoyment to be a significant predictor of Capability improvement ($b = .438$, $t(20) = 2.65$, $p = 0.016$). Those who reported to have enjoyed playing a motion-sensor game showed significant increases in Capability ($Z(17) = -2.028$, $p = 0.043$ [from 5.509±1.23 to 5.92±.89]) but not Opportunity ($Z(17) = -.342$, $p = 0.733$) or Motivation ($Z(14) = -.977$, $p = 0.329$) scores.

The responses for all of the instrument items from data from participants who completed the questionnaire on both arrival and on departure from the camp can be found in Supplementary Table 1. This table displays correlations between questionnaire item response scores collected on arrival at, and on departure from the camp. All had a Spearman's coefficient greater than .35, and all except two ("I know how much exercise I should do to stay healthy" and "Most of the people I know do exercise often") were statistically significant. Each coefficient reflecting the three respective composite domain correlations between the two times the questionnaire was completed was greater than .5 and statistically significant.

COM-B exercise scale scores predicted post-camp weight-loss. BMI SDS reduction was associated with participants' final Capability ($b = -.552$, $t(11)= -2.197$, $p = 0.050$), Opportunity ($b = -.615$, $t(10) = -2.466$, $p = 0.033$) and Motivation ($b = -.669$, $t(9) = -2.702$, $p = 0.024$) composite scales, with higher scores predicting more successful long-term weight-loss in each case.

Discussion

The COM-B exercise questionnaire domains were found to have adequate internal consistency and construct validity, and elicited predicted findings of an inverse relationship between PEC and BMI SDS across each of the two study samples. No relationship between BMI SDS and motivation or opportunity was found in either sample. The small-scale intervention described in Study 2 demonstrated how the questionnaire can be used in the context of an obesity-related intervention. The preliminary findings of this pilot study suggest that it may be possible to improve PEC through intervention, and that there may be a positive association between perceived exercise capability, opportunity and motivation and weight-loss success. Future research, using larger-scale studies could investigate these possibilities further.

PEC is the focus of this article, but we do not suggest that motivation and opportunity are unimportant factors in encouraging exercise for obese children, indeed these factors are essential for behaviour to occur (as demonstrated by evidence in the literature(8, 9), and as suggested by preliminary findings presented in Study 2). However, findings presented here suggest that capability is a function that is particularly useful to target when aiming to elicit a greater level of physical activity from obese children, further to adding to previous evidence that PEC is key in predicting childhood obesity(2).

Although the questionnaire was found to have adequate construct validity overall, the RMSEA was above .06, indicating a 'moderate' rather than 'good' fit(18, 19). This may have been due to the relatively small sample size in this study: there is evidence that the recommended cut-offs for RMSEA can be overly restrictive for small-sample studies(17). Future research involving distribution of the questionnaire to a larger sample may result in construct validity, and in particular parsimony of fit being more decisively established.

We also recommend that future research investigates test-retest reliability of the questionnaire. Findings presented here provide preliminary evidence for test-retest reliability: Despite the questionnaire being administered to a small sample before and after an intervention designed to change the participants' beliefs about exercise, most items collected post-intervention were significantly correlated with the pre-intervention score, and all composite domain scores collected post-intervention were found to have highly significant correlations with equivalent pre-intervention scores. The two items that were not found to significantly correlate with one another were “I know how much exercise I should do to stay healthy” and “Most of the people I know do exercise often”. These items seem to be highly likely to have been affected by the intervention. Attending a weight-management camp is likely to result in the attendee getting to know more people who frequently conduct exercise, and getting a better idea of recommended guidelines for exercise. Future studies from a larger sample of participants who are not undergoing any intervention could investigate test-retest reliability further.

Rather than simply measuring PEC, this study describes PEC measurement within the COM-B model, which accounts for the complete breadth of factors that influence behaviour. This study therefore builds on previous evidence that PEC and capability are linked by a) demonstrating an inverse correlative relationship between BMI and PEC; and b) indicating PEC to be of greater importance in predicting childhood obesity than factors relating to opportunity or motivation.

PEC describes an individual’s belief they are capable of carrying out exercise, so it is a similar concept to ‘self-efficacy’, which is an individual’s belief that they are able to succeed in certain situations(23). However, the COM-B framework was developed with the aim of capturing all factors that can influence behaviour(9) and capability, by its definition is separate from the remaining parts of the framework: opportunity and motivation. Therefore, when PEC is measured within a COM-B scale, it can be separated from, and compared with the remaining factors of the framework, whereas it is less clear how self-efficacy overlaps or does not overlap with other factors that relate to behaviour change.

We suggest that compartmentalising and measuring key drivers of behaviour, by using a framework such as COM-B, can inform the design and implementation of health interventions, which can take many forms. We advocate a systematic approach to behaviour change design and suggest future work should be done to further investigate the link between PEC and childhood obesity, and how PEC in obese children can be improved.

Conclusions

Evidence is presented for feasibility of measuring beliefs relating to exercise according to COM-B using a questionnaire, as part of a childhood obesity intervention. A questionnaire was constructed which was found to have adequate internal consistency and construct validity. Findings indicated lower PEC to be associated with higher BMI SDS; future research could investigate the link between PEC and childhood obesity further.

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