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Association of Liking and Reinforcing Value with Children's Physical Activity

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Abstract

Roemmich, J.N., J.E. Barkley, L.H. Epstein, C.L. Lobarinas, J.H. Foster, and T.M. White: Association of Liking and Reinforcing Value with Children's Physical Activity. *Physiol Behav* 00 (0) 000-000, 2007 – This study determined whether liking and relative reinforcing value (RRV) of physical activity were associated with time youth spend in moderate-to-vigorous physical activity (MVPA). Boys ($n = 21$) and girls ($n = 15$) age 8 to 12 years were measured for height, weight, aerobic fitness, liking and RRV of physical activity, and minutes in MVPA using accelerometers. Independence of liking and RRV of physical activity was established by a low correlation ($r = 0.08$, $p = 0.64$). Using MVPA as the dependent variable and hierarchical regression to control for individual differences in age, aerobic fitness, and time the accelerometer was worn in step 1 (R^2 of 0.60 for step 1), addition of liking and RRV of physical activity in step 2 produced an incremental increase in R^2 of 0.12 ($p < 0.01$). When using median splits of the RRV and liking data to form subject groups, children with both a high liking and RRV of physical activity participated in greater ($p \leq 0.02$) MVPA (1340 ± 70 min/week) than children with high RRV-low liking (1040 ± 95 min/week), low RRV-high liking (978 ± 88 min/week), or low RRV-low liking (1007 ± 68 min/week) of physical activity. Thus, liking and RRV of physical activity are independently associated with MVPA. The combination of a high reinforcing value and liking of physical activity is associated with 33% greater participation in MVPA.

Keywords

enjoyment; reinforcement; MVPA; behavioral economics

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INTRODUCTION

Participation in regular physical activity has multiple health benefits for youth [1]. Engaging in moderate-to-vigorous physical activity (MVPA) may be especially important for the health of youth as more intense physical activity may provide the greatest health benefits [2]. Many children however, do not participate in adequate MVPA to receive its full health benefits [3] and research is needed to develop a better understanding of factors associated with usual MVPA of a child.

Many factors may influence the choice to be active, and one theoretical approach to choosing to be physically active is behavioral economics [4]. Behavioral economics theory is designed to understand factors that influence choice among alternatives. Two important factors in choice are the reinforcing value (i.e., motivating value) of, and access to, the alternatives [4]. One way that reinforcing value of a behavior is measured is by preference, in effect, the relative amount of motivated responding the individual is willing to engage in to gain access to one of two alternatives [5–7]. A highly reinforcing behavior will support relatively more responding to obtain the behavior. If engaging in one behavior is much more reinforcing than another, and access to both behaviors is equal, most children will choose the more reinforcing behavior. Similarly, if the reinforcing value is equal, but access to behaviors differs, then children are likely to choose the behavior with easier access [4]. Some children find physical activity more reinforcing than others [8] and individual differences in the reinforcing value of physical activity are associated with usual physical activity in children [9].

Another factor that may be associated with physical activity participation is liking of physical activity. Liking or hedonics refers to an affective rating associated with the behavior [10–13], and people may be more likely to engage in behaviors that they like than ones that they do not like. Liking is associated with physical activity in youth [14–17].

Based on studies of eating behavior and drugs of abuse, the motivation to consume a food or drug and the liking of the food or drug effects are different constructs, which may be mediated by different neurobehavioral systems [10–13]. Berridge and Robinson [10–12] have proposed that ‘wanting’ of food, a construct different from reinforcing value, is related to central dopamine activity. Wanting describes the incentive salience or “stimulus-guided goal directed” motivation to consume a reinforcer, and is usually measured in paradigms in which the reinforcer is not available. Salamone extends this model by suggesting that ‘wanting’ includes the appetite to consume a reinforcer as well as the instrumental performance to obtain the reinforcer [13], as measured by the RRV task in the present study. Liking is a measure of the hedonic value of the behavior, and is mediated by opioid responses [10–12]. Berridge and Robinson [11,12] review the supporting literature for the role of ‘wanting’, an index of motivational process, and ‘liking’ for the consumption of food and addictive drugs. Salamone and Correa [13], however, discuss the evidence that dopamine antagonists and nucleus accumbens dopamine depletions do not affect behavior directed towards the acquisition and consumption of food *per se*, but does alter effort-related choice, shifting choice to lower-cost less preferred foods. Research suggests that wanting is a stronger predictor of energy intake than liking in animals [18] and reinforcing value is a stronger predictor of energy intake than liking in humans [19,20]. Reinforcing value has been related to usual physical activity [9], but to our knowledge there is no research that has tested whether the relative reinforcing value (RRV) and liking aspects of physical activity are independently associated with participation in MVPA or the relative importance of each component for children’s usual participation in more vigorous types of physical activity.

Previous research on choice of active versus sedentary behaviors suggests they are different and independent constructs. In our activity choice experiments we generally include sedentary

behaviors and physical activities that are equally liked, but children still choose to respond for sedentary rather than physically active alternatives [8]. Given the potential independent associations of RRV and liking on youth physical activity those children who have both a high RRV and liking of physical activity may engage in more MVPA than other children. To develop a better understanding of physical activity motivation in humans it is important to determine whether RRV and liking of physical activity have independent associations with time in MVPA. Understanding the association of these variables with physical activity may lead to new theory based interventions to effectively increase physical activity behavior. Thus, in the present study we sought to determine the associations of RRV and liking with MVPA.

METHODS

Subjects

Children were recruited from targeted mailings for a longitudinal study designed to test the efficacy of wearing an accelerometer and self monitoring to increase physical activity. This paper presents a cross-sectional analysis of the baseline data of the 21 boys and 15 girls of age 8 to 12 years who participated in the longitudinal study. The sample consisted of White ($n = 31$), Black ($n = 3$), and Asian ($n = 2$) children. All children were below the 85th percentile for body mass index (BMI) and had no conditions that limited physical activity. To limit the effect of weather on physical activity, all measurements occurred during the school year in either the spring ($n = 25$) or fall ($n = 11$) seasons. There was no difference ($P = 0.67$) in MVPA between children measured in the spring and fall seasons so the data were combined. Parents gave written informed consent while children gave their assent for study participation. This study was approved by the Children's Hospital of Buffalo, Children and Youth Institutional Review Board.

Procedures

Children reported to the laboratory and were measured for height and weight. Trained staff evaluated each child's relative reinforcing value and liking of exercise, and their cardiovascular fitness. Children were fitted with an accelerometer to determine usual MVPA for seven consecutive days. Upon returning to the laboratory, a research assistant downloaded and thoroughly reviewed the activity data with the child and parent.

Measurement

Demographics—Race and ethnic background were obtained using a standardized questionnaire [21].

Anthropometrics—Body weight was measured to the nearest 0.01 kg with the children wearing shorts and a t-shirt. Height was assessed using a calibrated stadiometer to the nearest 1.0 mm. Height and weight data were used to determine body mass index (BMI) and percent overweight. BMI was calculated according to the formula $BMI = \text{weight in kg} / \text{height in m}^2$. BMI percentile was calculated based on each child's gender and age [22].

Cardiovascular fitness—Aerobic fitness was determined by completing a physical working capacity 170 test (PWC170) where the dependent measure was the oxygen consumption in $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ attained at a heart rate of 170 $\text{beats} \cdot \text{minute}^{-1}$ while walking on a treadmill. Before beginning the fitness testing protocol children were given instruction and practiced until they were comfortable walking on the treadmill. Children completed the PWC170 protocol consisting of a 3 minute stage at 3.2 mph, 0% grade; and 3 minute stages at 3.7 mph and 2.5%, 5.0%, 7.5%, and 10% grade until their heart rate reached at least 170 $\text{beats} \cdot \text{minute}^{-1}$. For each child, heart rates at 3 or more workloads that elicited heart rates greater than 110 $\text{beats} \cdot \text{minute}^{-1}$ were regressed with the corresponding oxygen consumption

data to determine the oxygen consumption ($\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) at a heart rate of 170 beats $\cdot \text{minute}^{-1}$. Heart rate and metabolic data were collected every 60 seconds via heart rate telemetry (Polar, Port Washington, NY) and standard indirect calorimetry (Vmax, Sensor Medics, Anaheim, CA), respectively. Each child wore an accelerometer (BioTrainer; Individual Monitoring Systems, Baltimore, MD) during the PWC170 test to determine the count intensity that corresponded with an exercise intensity of 3 METS (MVPA). The count intensity threshold of three METS for each child was determined by regressing their MET and accelerometer count intensity values from the PWC170 test.

Physical activity—Children wore Biotrainer-Pro accelerometers (Individual Monitoring Systems, Baltimore, MD) attached to a belt with a pouch for a minimum of four hours per day outside of school hours on school days and a minimum of six hours per day on weekends for seven consecutive days. Wearing the monitor was limited to before or after school on weekdays to measure spontaneous or planned activity of the child's choice and not activity that was part of a school curriculum. Children who did not go home directly after school took the monitor with them in their backpack and put it on after school hours. Seven consecutive days of activity monitoring provide valid estimates of participation in MVPA [23]. Data were collected at a sample rate of 10 Hz with an epoch of 1 minute. The accelerometer can be initialized at sensitivity levels of 1 to 40, representing the sensitivity of the monitor in relation to the data display. The sensitivity is set at a lower setting if vigorous activity is anticipated to be measured. Each accelerometer was initialized at a sensitivity of 4 since the sample consisted of children, who are naturally active in frequent bouts of intense activity [24]. Each child was fitted with a belt and wore the monitor at the hip and snug against the body. Parents were instructed to ensure that their child wore the monitor in the appropriate fashion each day. The monitor was not worn during sleep; or when bathing, showering, or swimming as the unit is not waterproof. The intensity of each activity count was determined with software provided by the manufacturer. Activity counts three METS or greater in intensity, as determined during the PWC170 test, were recorded as MVPA and served as the dependent variable in this study. In 8 to 12 year old children Biotrainer Pro g values and oxygen consumption are highly correlated at $r = 0.96$ [25].

Liking and relative reinforcing value—Children were provided access to three physical activities, cycle ergometer (CatEye USA, model EC 1600, Boulder CO), stepper (Precor USA, model 718e, Woodinville, WA), twist-&-ski (NordicTrack) and three cartoon vignettes (Sponge Bob Square Pants™, Jimmy Neutron™, Fairly Odd Parents™) in counterbalanced order for 1 minute each. An investigator demonstrated how to use each piece of exercise equipment. Each child rated their liking of each activity and cartoon using a 10 cm visual analog scale (VAS) anchored by “don't like at all” and “like very much” immediately after sampling them. The physical activity and cartoon with the greatest liking score were used in the choice task. To the best of our knowledge there are no data regarding the validity of VAS methods for assessing the liking of activities. However, VAS scores for the measurement of feelings and opinions regarding school, sports, and height correlate with numeric VAS scores with a coefficient of 0.80 and with Likert scales with a coefficient of 0.76 [26].

After completing the liking ratings, the RRV of physical activities to sedentary behavior (watching cartoons) was assessed. First, children sampled pressing a handheld counter by pressing a button with their thumb at a rate of one press per second using a metronome to keep the rate of button presses constant. Children then completed a questionnaire choosing whether to respond, by completing button presses, for time to watch their most highly rated cartoon or their most highly rated physical activity. The questionnaire consisted of 16 questions. For each question the child was given a choice between the number of times they were willing to press a button on the counter to gain 10 minutes access to their most highly rated videotaped cartoon or to gain access to their most highly rated physical activity. For cartoons the number of button

presses started with 20 for question number 1 and increased by an additional 20 presses for each subsequent question until a total of 320 button presses was required for question 16. For physical activity the number of button presses remained at 20 for all questions. Sedentary activities are more reinforcing than physical activities so children will not switch to working for physical activities unless the response requirement for access to sedentary activities increases beyond that of physical activities. For example, for question 5 the child was asked to make the choice between pressing the counter button 120 times for access to videotaped cartoons or perform 20 presses for access to physical activities. Children circled the choice that they would rather do for each question. To increase accuracy of responding children were instructed that they would have to pull a number out of a bag that corresponded to one of the questions and that they would then have to perform the button pushes and then the activity that they circled for that question. The questionnaire was scored as the number of presses at which a child switched from a willingness to respond for watching their most highly rated cartoon to working for engaging in their most highly rated physical activity. The fewer the button pushes the child was willing to perform to gain access to cartoons was interpreted to indicate a greater RRV of physically active versus sedentary alternatives.

This questionnaire has been validated against a computer controlled laboratory concurrent schedules choice task in which children responded for access to sedentary or active alternatives on progressive ratio schedules of reinforcement [27]. The physical and sedentary activities presented to the children were those that they could perform in the laboratory by themselves. The purpose of the task was to determine, in general, the motivation to be physically active versus sedentary. Although each child's most highly rated physical activity choice and cartoon choice were used during the task, they may have had more preferred physical activities and sedentary behaviors than those available in the laboratory setting. The external validity of this general approach is provided by previous research that employed a similar computer-based task and concurrent reinforcement schedules where children pressed a joystick button to earn time to engage in physically active or sedentary alternatives [9]. When the reinforcement schedule for physical activity was held at a variable ratio (VR) of 2 (VR2) and the response requirements for the concurrently available sedentary activities increased from VR2, VR4, VR8, and VR16, the RRV of physical activity was associated with the free-living amount of physical activity ($r = 0.42$, $P \leq 0.05$) [9].

Analytic Plan

Descriptive statistics were completed to summarize the demographics (age, height, weight, BMI, BMI percentile, PWC 170), liking of sedentary behavior and physical activity, RRV of physical activity, and time in MVPA of the combined group of boys and girls. The univariate correlation between the liking and RRV of physical activity was $r = 0.08$, $p = 0.64$ confirming low colinearity so both variables were entered into subsequent regression analyses. A hierarchical linear regression model was employed to determine whether addition of information regarding RRV of physical activity and liking of physical activity improved R^2 for time in MVPA beyond sex, age, BMI percentile, aerobic fitness, and time the accelerometer was worn. To develop the most parsimonious model only significant ($p \leq 0.05$) control variables were retained. As a result sex of the child ($p = 0.45$) and BMI percentile ($p = 0.27$) were removed from the model. To explore the relationships between RRV and liking of physical activity on MVPA participation, children were assigned to high RRV-high liking, high RRV-low liking, low RRV-high liking, or low RRV-low liking of physical activity groups based on median splits of the RRV of physical activity and liking of physical activity data. A two-way ANOVA (liking group by RRV group) was then performed to test for main and interaction effects on time in MVPA while covarying for the same significant variables (age, aerobic fitness and time the accelerometer was worn) used in the hierarchical regression model. The significant interaction was explored with linear contrasts. The main and interactive effects of RRV and

liking of physical activity on MVPA participation were also explored using multiple linear regression that included the same covariates as the above models, but allowed for the continuous nature of the liking and RRV variables.

RESULTS

Subject demographic and physical activity data are listed in Table 1. The hierarchical regression results for the association of RRV and liking with MVPA are shown in Table 2. The step 1 block of variables produced an R^2 of 0.60 ($p < 0.001$). Addition of RRV of physical activity and liking of physical activity in step 2 resulted in an incremental increase in R^2 of 0.12 ($p < 0.01$). From the ANOVA analysis there was a significant ($p \leq 0.05$) RRV group by liking group interaction that is illustrated in the Figure. Linear contrasts revealed that children with both a high liking and RRV of physical activity participated in greater ($p \leq 0.02$) MVPA (1340 ± 70 min/week) than children with high RRV-low liking (1040 ± 95 min/week), low RRV-high liking (978 ± 88 min/week), or low RRV-low liking (1007 ± 68 min/week) of physical activity. In addition, there was a main effect for RRV group ($p \leq 0.03$), but not for liking group ($p \geq 0.10$) for minutes of MVPA. Children in the high RRV group (1190 ± 60 min/week) engaged in a greater MVPA than children in the low RRV group (993 ± 56 min/week). The multiple linear regression results using RRV and liking as continuous variables agreed very closely with the ANOVA results in that again there were independent main effects of liking ($p < 0.05$) and RRV ($p < 0.05$) for time in MVPA. There was also a significant ($p < 0.05$) liking by RRV interaction effect for time in MVPA.

DISCUSSION

As evidenced from the weak correlation ($r = 0.08$, $p = 0.64$) between the RRV (i.e., motivating value) and liking of physical activity they are independent constructs in normally active children. Research has demonstrated that both RRV [9] and liking [14–17,28] of physical activity are associated with the amount of physical activity that children engage in. This study extends previous research by including measures of both RRV and liking of physical activity and demonstrating that RRV and liking are independently associated with time in MVPA. The results also demonstrate that children who have both a high RRV and liking of physical activity engage in greater MVPA than other children. Liking of a food or drug is thought to be primarily related to opioid system while the appetite to consume a reinforcer as well as the instrumental performance to obtain the reinforcer is primarily regulated by the dopamine system [13], though the activity of both systems is interrelated [10–12].

The hedonic and motivational aspects of rewards usually go together, as people usually like what they want [11]. Liking of physical activity may be more related to the types of physical activity, sports, or games children choose to engage in. Reinforcing value, on the other hand, may be more related to the behavioral effort or how hard a child will work to engage in their most liked physical activities. It makes sense that children are more likely to engage in behaviors that they like and that they are motivated to obtain. Many children may report that they like a physical activity, but do not put forth the effort to engage in that activity.

This identification of unique although overlapping, neural systems suggests that motivation for physical activity may also be influenced by multiple neurobiological systems. Central dopamine release, dopamine D2 receptor (DRD2) number, and synaptic dopamine transporters have been investigated for their role in physical activity motivation given the importance of dopamine for controlling central motivational responses [10–12,29,30] and motor movement [31–33]. DRD2 antagonists reduce total motor activity by up to 41% in healthy adults [34] and DNA sequence variations in the DRD2 gene are associated with reduced total motor activity levels in women [35]. Imaging studies in adults have shown that DRD2 [36] and dopamine

transporters [37] are reduced with age and that age-related reductions in DRD2 availability are correlated with reduced motor function [38]. However, 30 minutes of running was found to have no effect on their brain dopamine activity [39]. Wheel running by rats and other small animal models occurs spontaneously and is a reinforcing behavior in that they will perform lever presses to engage in wheel running [40–43]. Moreover, wheel running produces a reinforcing aftereffect as measured by conditioned place preference after the exercise has stopped [43]. In small animal models increased synaptic dopamine concentrations through inhibition of dopamine transporter action increases locomotor activity [44], whereas DRD2 receptor deficiency or pharmacologic blockade or knockout of DRD2 reduces locomotor activity [31–33].

Research regarding alterations in the opioid system during exercise has also been conducted. Exercise increases peripheral endogenous opioids in humans [45,46] and central opioids in animal models [46–48]. Exercise increases central beta-endorphin release [48] and dynorphin mRNA [49] in small animal models. Although opioid agonists generally increase locomotion in laboratory animals [50], opioid antagonists have generally had little effect on the amount of locomotion in open-field tests [51,52]. In contrast, voluntary wheel running [53] and conditioned place preference produced by wheel running [54] in animals that have established the behavior, as well as the initial acquisition of wheel running behavior [55] are all attenuated by opioid receptor antagonists.

Running and other MVPA-type exercises produce discomfort originating from the active muscles [56,57]. One way opioids may be related to the hedonics of physical activity and participation in MVPA is by reducing the pain that typically occurs during exercise [57–61]. Peripheral endogenous opioids may also help to maintain blood glucose concentrations [62–64] and muscle contractile function during vigorous exercise [65], which would also help to reduce muscular discomfort. Another way endogenous opioids may influence the hedonic aspects of MVPA is by promoting exercise-induced increases in mood [66,67].

Based on the above findings and dopamine system physiology [68] some combination of greater DRD2 receptor number, ample synaptic dopamine release, and slower synaptic dopamine reuptake would be expected to promote a higher reinforcing value of MVPA. Characteristics of the central opioid system such as an increased number of opioid mu receptors and greater neuronal release of endogenous peptides including enkephalins, dynorphins and endorphin would be expected to promote a greater hedonic value or sensory pleasure during MVPA [69]. In contrast, children who have lower central dopamine or opioid signaling may not engage in as much MVPA due to a lower reinforcing value or liking of more vigorous types of physical activity.

Additional research is needed to better understand the role of the central dopamine and opioid systems for engaging in MVPA. Central dopamine and opioid systems have been primarily studied for their roles in eating and drugs of abuse [10–13]. Some evidence suggests that there may be differences in the neural mechanisms for the motivation to eat and to be physically active. Studies of children (Temple, Legierski, Giacomelli, Salvy & Epstein, unpublished results) and adults [19,20] have found that the RRV of food was more strongly associated with energy intake in *ad libitum* eating tasks than liking for food. In contrast, the present study found that both RRV and liking of physical activity were independently associated with physical activity participation and that MVPA was greatest only when the individual had relatively high RRV and liking of physical activity. These results suggest that RRV and liking may have different amounts of influence on MVPA than on eating.

The present results can be generalized to normally active youth in that time in MVPA of the children in the present study is very similar to previous studies that used accelerometers to

measure MVPA in 8 to 12 year old children [23,70–72]. Although some studies have reported much lower time in MVPA [73], this appears to be a function of the method used to define MVPA [70]. As shown by Guinhouya and colleagues [70] using the cutoff regression equations of Freedson and colleagues [74] produces MVPA minutes that agree quite well with the current study while using the cutoff values of Puyau [75] results in 5-fold lower estimates of MVPA. The current study has the advantage of having each subject walk and jog on a treadmill while collecting oxygen consumption data and wearing the accelerometer that they wore during the week of monitoring to determine individualized 3-MET MVPA cutoffs for each subject. This method produced MVPA data that not only agree with the method of Freedson and colleagues [74], but also agree with time in MVPA calculated from an independent method, heart-rate monitoring, measured across 26 studies that included 1883 youth [3].

However, other aspects of the study limit generalization. All the participants were normal weight, and it is possible that different results would be obtained if overweight children were studied. The subjects' history of physical activity or participation in sports was not assessed. History of physical activity may have influenced the subject liking and/or reinforcing value of physical activity. In addition, the measurements of liking and RRV were limited to the activities that were studied, and different results might be obtained if different sedentary and physically active alternatives were studied. One major advantage of the questionnaire is that it greatly expands the types of activities that can be assessed in future studies. The questionnaire can be used to ask children to choose between more activities, such as soccer and tennis that cannot be replicated in the laboratory. Another limitation is that there are no data regarding the validity of VAS methods for assessing the liking of activities.

An alternative interpretation of the data is that the allocation of responding for the sedentary versus the active alternative could be due to avoidance of physical activity due to aversive characteristics of physical activity, rather than low reinforcing value of being active. There are characteristics of physical activity that may be aversive and lead to avoidance, such as poor performance, sweating, discomfort or pain, and later muscle soreness. It would be interesting to test whether low response rates for physical activity were due to low reinforcing value of this alternative, or avoidance of being active due to aversive qualities of physical activity. The most direct way to test this would be to arrange an experimental paradigm to assess whether physical activity serves as an aversive stimulus which can reduce the rate of behavior that it follows.

In conclusion, we have examined the association of RRV and liking of physical activity with the usual participation in physical activity of children. The RRV and liking of physical activity were independently associated with time in MVPA. This is the first example of a separation between the reinforcing value and liking of physical activity in children. Children who have both a high reinforcing value and liking of physical activity engage in greater MVPA than other children. The reinforcing value and liking of physical activity may play an important role in influencing the amount of MVPA children perform. A better understanding of how the reinforcing value and liking of activity develops, as well as methods to make physical activity more reinforcing and liked may improve our efforts to help youth be more physically active and derive the health benefits associated with an active lifestyle.

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Figure.

Minutes of moderate-to-vigorous physical activity (MVPA) per week of groups of children with a high relative reinforcing value (RRV) and high liking of physical activity, high RRV and low liking of physical activity, low RRV and high liking of physical activity, and a low RRV and low liking of physical activity. High and low RRV and liking groups were based on median splits of the RRV of physical activity and liking of physical activity data. *Children with a high RRV and high liking for physical activity engaged in a significantly greater ($P \leq 0.05$) number of minutes of MVPA per week than all other groups of children. There was also a main effect for RRV group ($P \leq 0.03$). Children in the high RRV group engaged in greater MVPA than children in the low RRV group. Data are mean $\pm$ standard error.

Table 1

Subject demographics and physical activity

Chronological age (years)	10.9 ± 1.4
Height (cm)	144.6 ± 11.9
Weight (kg)	37.5 ± 8.9
BMI (kg/m ²)	17.9 ± 2.1
BMI percentile	52.7 ± 27.3
PWC 170 (ml/kg/min) *	27.7 ± 4.1
Liking of watching cartoons (cm) [#]	7.2 ± 2.0
Liking of physical activity (cm) [#]	8.0 ± 2.0
RRV of sedentary to physical activity (presses) **	66.1 ± 68.6
Time in MVPA (minutes/week) ^{##}	1108.4 ± 398.3

Data are mean ± standard deviation.

* PWC170: performance work capacity (oxygen consumption) at a heart rate of 170 beats per minute.

[#] Liking of physical activity and sedentary behaviors was measured using 10 cm visual analog scale. A greater score indicates greater liking of the behavior.

** RRV of sedentary to physical activity: relative reinforcing value of sedentary compared to physical activities. Greater RRV score indicates a greater number of presses (amount of work) that children were willing to perform to gain access to the sedentary alternative.

^{##} Time in MVPA: minutes of moderate-to-vigorous physical activity.

Table 2

Hierarchical regression to predict minutes of moderate-to-vigorous physical activity

	B	β	R² (unique)
Step 1			0.60 [*]
Age (years)	-66.18	-0.23	
PWC170 (ml/kg/min)	27.69	0.29	
Monitor time (minutes)	0.37	0.48	
Step 2			0.12 [*]
Liking of physical activity (cm)	54.39	0.27	
RRV of sedentary to physical activity (presses)	-1.51	-0.26	
Model R² = 0.72, P ≤ 0.001			

* $P \leq 0.01$ for incremental increase in R²

RRV of sedentary to physical activity: relative reinforcing value of sedentary compared to physical activities. The negative coefficient indicates that the less work (fewer button presses) children were willing to perform to engage in television watching before choosing to work for physical activity the greater their participation in moderate-to-vigorous physical activity.