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Citation for published version (APA):

Rheel, E., Ickmans, K., Wauters, A., Van Ryckeghem, D. M. L., Malfliet, A., & Vervoort, T. (2021). The effect of a pain educational video intervention upon child pain-related outcomes: A randomized controlled study. *European Journal of Pain*, 25(10), 2094-2111. <https://doi.org/10.1002/ejp.1822>

Document status and date:

Published: 01/11/2021

DOI:

[10.1002/ejp.1822](https://doi.org/10.1002/ejp.1822)

Document Version:

Publisher's PDF, also known as Version of record

Document license:

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The effect of a pain educational video intervention upon child pain-related outcomes: A randomized controlled study

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Abstract

Background: Pain neuroscience education (PNE) has received increasing research attention demonstrating beneficial effects on pain-related outcomes in adults. Conversely, studies on the effectiveness of PNE in children are scarce.

Methods: This study investigated the effect of a pain educational video intervention on child pain-related outcomes (i.e. experienced pain intensity, pain-related fear and catastrophic worry about pain, pain threshold and pain knowledge) in healthy children undergoing an experimental pain task. Furthermore, the moderating role of children's demographic (i.e. sex and age) and psychological (i.e. baseline pain knowledge and anticipated pain intensity, pain-related fear and catastrophic worry) characteristics was examined. Participants were 89 children ($M_{age} = 11.85$, $SD = 1.78$), randomly assigned to either a condition whereby they were instructed to watch a brief pain educational video (i.e. experimental group) or to a control condition whereby they did not watch any video.

Results: Study findings revealed that accurate pain knowledge and pain threshold were higher amongst children in the experimental group compared to the control group. In contrast with expectations, no main effects of the video intervention were observed for experienced pain intensity, pain-related fear and catastrophic worry. Moderation analyses indicated that the video intervention contributed, in comparison with the control condition, to higher levels of pain knowledge amongst younger children only and to higher pain thresholds amongst boys only.

Conclusions: Further investigation is needed to optimize pain educational video interventions and to determine whether more beneficial outcomes can be found in clinical (i.e. non-experimental) situations and in children with persistent or recurring pain problems.

Significance: Examining the impact of pain educational interventions within a non-clinical setting is deemed particularly important given that adaptive pain coping strategies likely play an important role in preventing the development and maintenance of future maladaptive pain-related behaviour. Further, study findings provide preliminary evidence of baseline and demographic (i.e. age and sex) characteristics explaining differences in the effect of a pain educational video intervention in pain knowledge and pain-related experiences during experimental pain.

1 | INTRODUCTION

Pain neuroscience education (PNE), also called ‘therapeutic neuroscience education’ (Louw et al., 2015; Zimney et al., 2014) or ‘explain pain’ (Moseley & Butler, 2015) is an educational strategy facilitating patients’ biopsychosocial understanding of pain, including the contributing role of (neuro)physiological, psychosocial and environmental factors to pain (Moseley & Butler, 2015; Nijs et al., 2011). PNE educates patients about the nature of their pain experience in order to reconceptualize patients’ pain (Moseley & Butler, 2015), hence decreasing the individual’s threat value of pain and catastrophic thinking, and promoting a more active and adaptive coping strategy (Louw et al., 2016).

The current best evidence on PNE supports its beneficial effects in terms of reduced pain ratings (Louw et al., 2011, 2016), pain-related fear (Moseley & Butler, 2015), pain catastrophizing (Louw et al., 2011; Moseley & Butler, 2015), healthcare use (Louw et al., 2016) and enhanced pain knowledge (Louw et al., 2016) in adults with a wide range of chronic pain states. Preliminary evidence in children demonstrated converging findings, with pain educational interventions resulting in increased pain knowledge (Andias et al., 2018; Louw et al., 2018; Wager et al., 2018), less pain-related fear (Pas et al., 2020), less local pressure pain sensitivity (Pas et al., 2020) and more functional pain beliefs (Louw et al., 2018) within both clinical and non-clinical settings. However, findings on the effectiveness of pain educational interventions in children are scarce and null effects in both adults and children were observed as well (e.g. Andias et al., 2018; Meeus et al., 2010). In addition, to our best knowledge, no studies are available about the effect of a pain educational intervention in children undergoing an experimental heat pain task. In conclusion, more systematic research on the effectiveness of pain educational interventions in children is needed. In addition, findings amongst adults suggest that individual differences may be important in understanding the impact of PNE upon pain-related outcomes. For instance, it has been demonstrated that adult chronic pain patients with higher levels of education and younger age improve more in terms of pain knowledge than those that are lower educated or older (Pate et al., 2019). To date, research into key demographic or psychological variables that may moderate the impact of pain educational interventions in children is lacking.

This study examined the effect of a brief pain educational video intervention in a sample of healthy children undergoing an experimental pain task. Pain-related outcome measures included experienced pain intensity, pain-related fear and state (i.e. situation specific) catastrophic worry about pain, pain threshold and pain knowledge; i.e. a set of variables that have previously been examined in the context of adult and paediatric pain educational interventions (e.g. Louw et al., 2011, 2018; Pas et al., 2020). We, furthermore, examined the

moderating role of child’s sex, age and baseline (i.e. anticipated) levels of the outcome variables of interest in understanding the impact of the intervention. The pain educational intervention was delivered by means of a brief engaging video based upon PNE4Kids (Pas et al., 2018), a pain science curriculum developed to teach children about the underlying biopsychosocial mechanisms contributing to one’s pain (Pas et al., 2018). Feasibility of PNE4Kids has been demonstrated in healthy children (Pas et al., 2018) and subsequent pilot testing in children with functional abdominal pain showed that PNE4Kids resulted in less disability, fear and local pressure pain sensitivity in the short term (Pas et al., 2020). Video animations are assumed to enable ideal opportunities to engage children, as they facilitate complex and novel information processing and remove time-consuming and physical limitations of face-to-face delivery methods (Pate et al., 2020). We hypothesized that children in the experimental group watching the PNE4Kids-based video would demonstrate less pain intensity, pain-related fear, catastrophic worry and lower pain threshold with regard to the experimental pain task and would show higher pain knowledge compared to children in the control condition who did not watch any video. Given the preliminary nature of the current investigation, no a priori hypotheses were generated regarding the moderating role of child individual difference variables.

2 | METHODS

2.1 | Participants

This study is part of a larger trial investigating (1) the impact of a brief PNE-based video upon child pain-related outcomes, (2) the effect of child attention bias upon child pain memory bias and (3) the role of parental attention to child pain. This study is a randomized controlled study and only reports findings related to the first aim of the larger trial.

Between July and December 2019, 8- to 15-year-old children were recruited through schools, sports clubs and youth movements in the vicinity of Ghent University (Belgium), through social media calls (Facebook, WhatsApp, Instagram, e-mail lists) and through family and acquaintances of the researchers and research assistants (Master of Science students Experimental and Clinical Health Psychology, Ghent University). Children were excluded from participation in case of: (1) chronic pain (Pain in ≥ 1 anatomic region that persists or recurs for longer than 3 months (Treede et al., 2015)); (2) chronic illness (e.g. cancer, diabetes, asthma); (3) diagnosed developmental disorder (e.g. attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD)); (4) inability of child and parent to speak and read Dutch. In total, 56 schools, sport clubs and youth movements were contacted, of which 37 agreed to distribute flyers providing

information and contact details of the study for families interested in participating. Of the 151 families who were interested to participate, 14 families refused to participate and four children were not eligible to participate (one child with chronic pain, one child with ADHD and two children with ASD). Main reasons for refusal of participation were that the child felt too uncomfortable or anxious to perform the experimental pain task ($n = 6$) and/or lack of time due to work/family demands ($n = 12$). Another 20 families eventually cancelled their appointment or did not show up at the appointment, due to comparable reasons as described above. Of the 113 children and parents who took part in the larger trial, 90 children were randomly assigned to either the experimental group that watched the video ($n = 45$) or control condition in which children did not watch any video ($n = 45$). This randomization list was prepared by one of the experimenters (E.R.) through a random number generator (www.graphpad.com/quickcalcs/randomize1) with a 1/1 allocation ratio. Children as well as their parents (but not experimenters) were blinded to group allocation. The study sample consisted 89 children aged 8 to 15 years and one of their parents.

As previously described, this study was part of a larger trial. A priori sample size calculation showed to detect an effect size f^2 of 0.15, which is moderate with an 80% power ($\alpha = 0.05$), 55 participants were needed. We over-recruited to account for the possibility of a high dropout due to the technologically more difficult nature of the larger trial and the fact that the children had to undergo a heat pain task. A priori sample size calculation was done with G*Power 3.1.9.2 (Franz Faul, Kiel, Germany).

2.2 | Procedure

A schematic representation of the experimental procedure is presented in Figure 1. Participants were invited by phone by the research team and received standardized information about the experiment. The heat stimulation procedure was described, but the children nor the parents were informed beforehand that some of the children would see a video explaining pain. When the parent-child dyad provided verbal consent during the phone call, they were invited to the laboratory at Ghent University. Upon arrival at the laboratory, one of the experimenters accompanied the child and parent to the test room. Participants were explained that the study aimed at investigating "how children and their parents think and feel about the child experiencing pain". The heat pain procedure was described and the thermal heat stimulator was shown. All participants were reminded of their ability to withdraw participation at any time, whereafter written assent/consent was obtained from both the child and the parent. Experimenter 1 stayed in the test room together with the child, while experimenter 2 accompanied the parent to the

room next door. First, socio-demographic information of the child and parent was obtained from the parent and the child reported on pain experience in the last 2 weeks before study participation, both using an online Lime Survey questionnaire. Afterwards, baseline measures of the dependent variables (i.e. anticipated pain intensity, pain-related fear, pain knowledge and catastrophic worry) were completed on paper by the child. Next, children randomized to the experimental group watched the 15-min PNE4Kids-based video. Children assigned to the control group did not watch any video (due to other study objectives that are part of the larger trial) and immediately proceeded to the next phase, which was a short break together with the parent. This short break was implemented in the study procedure for objectives other than those of the current study. After the short break and prior to the heat pain task, all children's pain knowledge was assessed for a second time, followed by determining the children's (moderate) pain threshold for the heat pain task. Next, the heat pain task was initiated. After performing the heat pain task, the other outcomes were assessed for a second time (i.e. pain intensity, pain-related fear and pain catastrophizing thoughts experienced during the performance of the heat pain task). Upon study completion, the parent and child were reunited in the child test room and fully debriefed about the study aims. The total duration of the experiment was about 1h 30min. Each participant was compensated €25 for participating in this study. Ethical approval for this study was obtained from the Ethics Committee of the Faculty of Psychology and Educational Sciences of Ghent University, Belgium.

2.3 | Heat pain task

Children participated in an experimental pain task, including actual heat pain stimuli. The 'Contact Heat Evoked Potentials Stimulator (CHEPS) of the Medoc Neuro Sensory Analyser, Model TSA-II (Medoc Ltd. Advanced Medical Systems, Ramat, Yishai, Israel) was used for heat stimulation. This device produces heat stimuli with a thermode contact area of 572.5 mm². The stimulating surface of the thermode was attached to the inside of the children's non-dominant forearm using a Velcro strap. The heat stimuli were applied to the skin surface over a time period of 300 ms, with an accelerated velocity of 70°C/sec and a cooling rate of 40°C/sec. Heat stimuli were delivered at the child's moderate heat pain threshold, which was individually determined before the start of the actual pain task by the methods of limits. To optimize the flow and consistency of word usage of the current manuscript, the moderate heat pain threshold will be from here on referred to as the term "pain threshold". The performed heat stimulation task is an ethically approved and safe pain task that has been successfully used in previous laboratory-based studies with children (Caes et al., 2012; Hermann et al., 2006; Vervoort

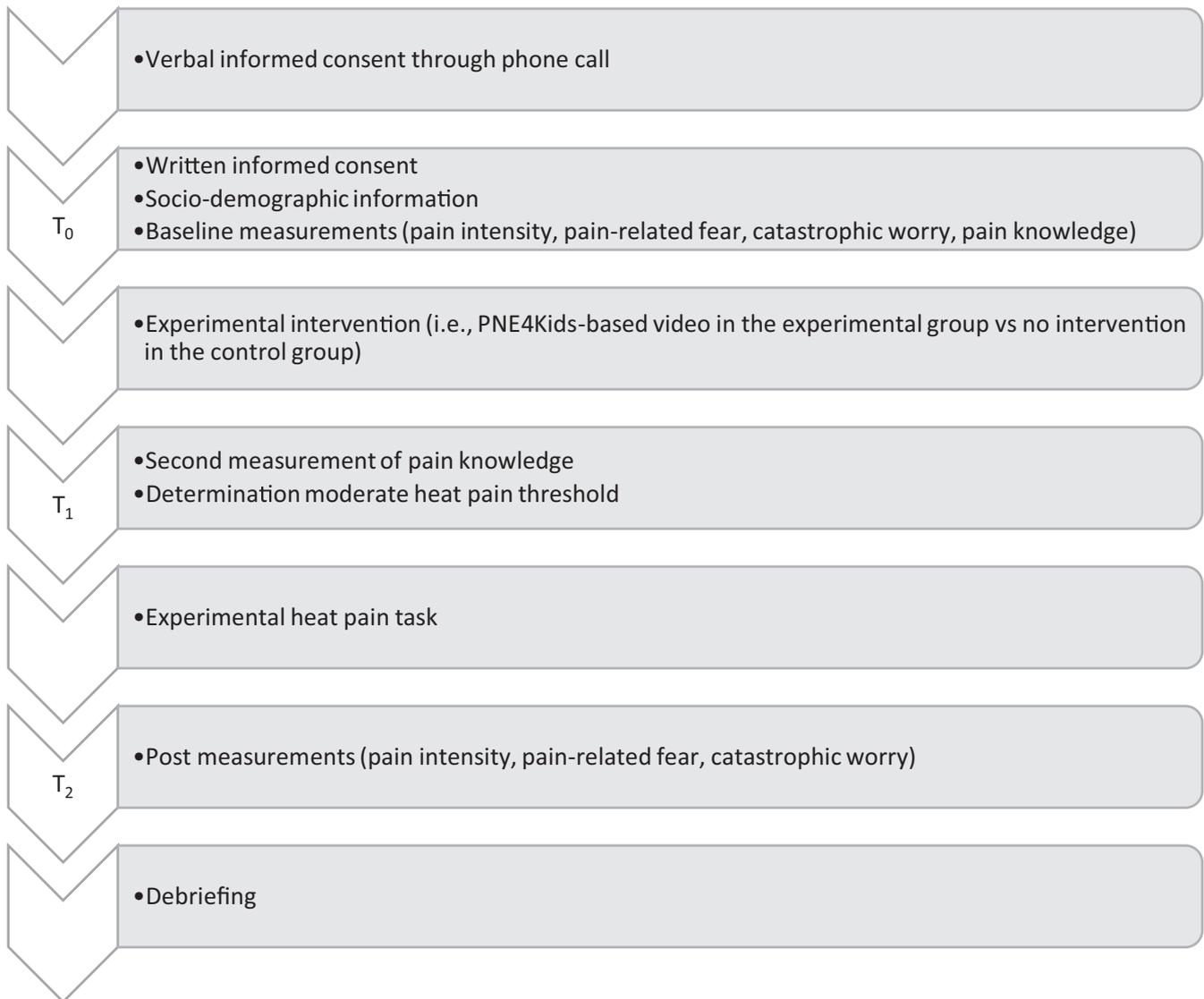


FIGURE 1 Schematic representation of the experimental procedure. T₀ = baseline upon the start of the experiment; T₁ = after the video intervention, upon the start of the heat pain task; T₂ = immediately after the heat pain task

et al., 2012; Zohsel et al., 2008). The detailed description of the experimental pain task can be found as Supplementary Material.

2.4 | PNE4Kids-based video

A 15-min pain educational video was developed, describing the neurobiology and neurophysiology of pain and pain processing. In order to make the video engaging and interactive, the children were invited to use accompanying materials (see Figures 2 and 3) according to the instructions in the video. The content of the video was based on the PNE4Kids curriculum (Pas et al., 2018) with four of the seven target concepts of PNE, as described by Leake et al., (2019) (Leake et al., 2019), being discussed in the video. The four included target concepts were as follows: 1) Pain is a protector, 2) Pain

is a brain output, 3) Pain is not an accurate marker of tissue state and 4) There are many potential contributors to anyone's pain. The concepts covered in the video were limited to these four target concepts given the nature of the study population (i.e. healthy school children without persistent pain symptoms), while the target concepts that were not included in the video may be considered more applicable for children suffering from persistent pain. Specifically, in the beginning of the video, the children experienced blindfolded which five senses humans have and how a feeling of pressure can turn into a feeling of pain by pressing a thumb nail with their index finger. Since metaphors and storytelling have shown to be very helpful tools in providing PNE (Gallagher et al., 2013; Moseley, 2007), the same metaphors and examples were used as in the PNE4Kids program (<http://www.paininmotion.be/pne4kids>) to educate the children about the structure and function of the nervous system, nociception



FIGURE 2 The lieutenant (i.e. neurochemicals within the synaptic cleft), operating the incoming messages at the elevator (i.e. spinal cord). © Reproduced with permission from Vrije Universiteit Brussel, Pain in Motion Research Group (PAIN)



FIGURE 3 The general (i.e. thalamus), managing incoming and outgoing messages at the computer room (i.e. brain). © Reproduced with permission from Vrije Universiteit Brussel, Pain in Motion Research Group (PAIN)

and nociceptive pathways, up- and down-regulation of the nervous system, while simultaneously using the provided materials as shown in the video (see Figures 2 and 3). More specifically, within PNE4Kids the nociceptive system, functioning as one of many body's protection mechanism, is represented as the army that protects the human body in real-life situations. Furthermore, in line with the PNE4Kids program, specific neurophysiological terms, such as action potential, nociception etc., are replaced by words that are comprehensible for children (e.g. 'the elevator of the body' instead of 'spinal cord'). In addition, the interactive board game of the PNE4Kids program was used to increase the therapist-child interaction during the education. Last, in the video used in this study two recognizable situations (i.e. a builder stepping on a nail and piercing his boot and a cyclist breaking his arm

during a race) that pain does not equal tissue damage and that incoming nociceptive messages can be modulated at different places within the nociceptive system (i.e. at the level of the elevator (i.e. the spinal cord) by the lieutenant and/or in the computer room (i.e., the brain) by the general).

2.5 | Measures

2.5.1 | Pain intensity

The child's anticipated and experienced pain intensity regarding the heat stimulation task was assessed using the Faces Pain Scale-Revised (FPS-R) (Hicks et al., 2001). This scale is a revised version of the original scale, which was developed by Bieri et al., (1990) for the self-assessment of pain severity by children (Bieri et al., 1990). The revised scale consists of six line drawings illustrating an increasing level of pain intensity from the most left face ("no pain at all") to the most right face ("most pain possible"). The scale is suitable for universal use as the faces do not display ethnic features and are age and sex neutral. The instructions of the FPS-R were read aloud by the experimenter. Participants responded by indicating (i.e. circling) which of the six faces corresponded best to their level of anticipated and experienced pain intensity (i.e. assessed at the beginning of the experiment and upon completion of the heat pain task, respectively). Faces were scored from 0 to 5. Adequate psychometric properties of the FPS-R have previously been demonstrated (Chambers et al., 1999, 2005; Goodenough et al., 1997; Stinson et al., 2006). Moreover, the scale is considered the most appropriate to measure acute pain intensity in children from the age of 4 (Hicks et al., 2001; Stinson et al., 2006) and has been used in Dutch paediatric samples previously (Brands et al., 2011; Wauters et al., 2020).

2.5.2 | Pain-related fear

The child's anticipated and experienced pain-related fear with regard to the pain task was assessed using the Children's Fear Scale (CFS). This scale is based on the Faces Anxiety Scale, developed by McKinley et al., (2003) (McKinley et al., 2003). This scale consists a row of five faces varying from a neutral face on the left ("not scared at all") to a face that shows extreme fear on the right ("most scared possible"). Similar to the FPS-R, the CFS is suitable for universal use as the faces do not display ethnic features and are age and sex neutral. The instructions of the CFS were read aloud by the experimenter. Participants responded by indicating (i.e. circling) which of the five faces corresponded best to their level of anticipated pain-related fear and experienced pain-related fear (i.e. assessed at the beginning of the experiment and

upon completion of the heat pain task, respectively). Ordered faces were scored from 0 to 4. The CFS has been shown to have a good inter-rater reliability and test–retest reliability, as well as construct validity in children (McMurtry et al., 2011) and has previously been used in Dutch paediatric samples (Wauters et al., 2020).

2.5.3 | Catastrophic worry about pain

Child' anticipated and experienced catastrophic worry about the heat stimulation task was assessed using an adaptation of the Pain Catastrophizing Scale for Children (PCS-C) (Crombez et al., 2003). Based on previous research (Birnie et al., 2016; Durand et al., 2017; Vervoort et al., 2009, 2011), we used a state version of the PCS-C, consisting of one adapted item from each of the three subscales (rumination: “To what extent do/did you keep thinking about how much pain the heat pain task could cause?”; magnification: “To what extent do/did you expect that, because of the pain, something serious would happen during the heat pain task?”; helplessness: “To what extent do/did you think you will not be able to endure the heat pain task because of the pain?”). Participants rated their anticipated (i.e. assessed at the beginning of the experiment) and experienced (i.e. upon completion of the heat pain task) thoughts and feelings regarding the heat stimulation task on an 11-point scale ranging from 0 (not at all) to 10 (extremely). Mean scores of these three items were calculated ranging from 0 to 10. Good internal consistency and reliability of the PCS-C State have been demonstrated in diverse child samples (Birnie et al., 2016). Cronbach's alpha (internal reliability) for the total 3-item PCS-C state questionnaire at baseline and after the pain task was 0.76 and 0.78, respectively.

2.5.4 | Pain knowledge

To assess children's pain knowledge at baseline and after watching the video (but before the pain task), a brief questionnaire was constructed for the purpose of this study. The questionnaire consisted eight statements and was constructed on the basis of the four target concepts of PNE that were incorporated in the PNE4Kids-based video (i.e. 1) Pain is a protector, 2) Pain is brain output, 3) Pain is not an accurate marker of tissue state and 4) There are many potential contributors to anyone's pain). Two statements were provided about each of the four discussed concepts, comprising one true and one false item (e.g. target concept ‘Pain is a protector’: 1) “Pain protects us”; 2) “It would be safer for our body if we could not feel pain”). The questionnaire items were not specifically related to the experimental pain task. Participants assessed each statement by means of a 5-point Likert scale,

ranging from 0 (“completely correct”) to 4 (“completely incorrect”), resulting in a maximum total score of 32. The items are in line with those of The Concept of Pain Inventory (COPI) that was still under construction at the beginning of this study (Pate, et al., 2020). To the best of our knowledge, no reliable and validated scale existed at the start of this study to measure pain knowledge in children.

2.5.5 | Pain threshold

Prior to the heat pain task, the child's pain threshold (°C) was determined by a staircase method. Starting from a baseline temperature of 32°C, the temperature was increased to a first target temperature of 42°C for 300 ms and returned to baseline at the end of the stimulus. Children were instructed to indicate with each heat stimulus if they perceived it as painful. When perceived as painful, the child had to indicate whether the pain was mild, moderate or severe. If the child indicated the pain as mild, the test phase continued to the subsequent target temperature, which was 1°C higher. This procedure was maintained until the child reported experiencing at least moderate pain. This moderately painful temperature was noted as the moderate pain threshold of the child. This staircase procedure was carried out twice. The stimulus with the highest temperature indicated by the child as at least “moderate pain” was used for the heat stimulation task. This moderate pain threshold stimulus was chosen to allow impact of top–down factors (e.g. cognitive processes such as attention bias, see second study objective), which may be compromised when using high intense pain stimuli (see also Van Ryckeghem et al., 2018). The moderate pain threshold (and not the first time the temperature was perceived as being painful) was used as outcome measure within this study provided that the initial starting temperature that was set at 42°C was already perceived as moderately painful by some children. In this way, a similar definition of pain threshold (i.e. moderately painful) applied to all children. For safety purposes, the Medoc software limits the maximum temperature of the heat stimuli to 54°C.

2.6 | Statistical analysis

Analyses were run with the statistical software IBM SPSS Statistics 27 (SPSS IBM, New York City, NY). A *p*-value of less than .05 (two-tailed) was considered statistically significant. Variables were examined for distributions and outliers based on a combination of Histograms, Q-Q Plots and skewness/kurtosis $-2/+2$, showing that variables met the assumptions of parametric tests without transformation or correction. Pearson correlations were performed to examine associations between the children's age, baseline and outcome measures.

To check the comparability of study groups (i.e. experimental group and control group) and differences between boys and girls, Independent *t*-tests were performed for the baseline assessments.

To investigate the impact of the PNE4Kids-based video intervention, hierarchical regression analyses were performed for each of the dependent variables, i.e., experienced pain intensity, pain-related fear and catastrophic worry, pain knowledge and pain threshold. Sex (boys coded as 0, girls coded as 1) and age of the children were included in the analysis in the first step of the regression analyses. In a second step, the centred baseline value of each of the dependent variables (except pain threshold) was added. Condition (control group coded as 0, experimental (i.e. intervention) group coded as 1) was entered in step 3 of the regression analyses. Finally, in step 4, the interaction terms between condition and each of the centred baseline variables (as entered within step 2 of the analyses) and child sex and age were added to examine the impact of the PNE4Kids-based video intervention as a function of these individual child differences. Significant interactions were further investigated by plotting and testing the regression lines' significance for high (+1SD above the mean) and low (−1SD below the mean) values of the continuous predictor variables following the procedure as described by Holmbeck (1997). This procedure does not categorize participants into two groups but allows, by manipulating the 0 point of the moderator, to examine conditional effects of the continuous moderator variable upon the outcome. To this end, two steps were performed. First, two new conditional continuous moderator variables were computed by (1) subtracting 1 SD from the centred moderator variable (to compute 'high levels' of the continuous moderator variable) and (2) adding 1 SD to the centred moderator variable (to compute 'low levels' of the continuous moderator variable). Second, two additional regression analyses were performed, incorporating each of these new conditional continuous moderator variables, to test the significance for high and low values of the conditional moderator variables. Variance inflation factors of all regression analyses were acceptable (range 1.04–3.63) suggesting that there was no problem of multicollinearity.

3 | RESULTS

3.1 | Participant flow

Ninety children were randomly assigned to either the experimental group that watched the video ($n = 45$) or control condition in which children did not watch any video ($n = 45$). Complete data are available for 84 children. One participant ended participation before watching the video and was, therefore, excluded from the study. Five other children performed an invalid heat pain task due to technical problems or stopped

participating after a few heat stimuli because they were too anxious, and thus did not provide data on pain threshold and experienced pain intensity, pain-related fear and catastrophic worry about pain. Therefore, data for pain knowledge were available for 89 participants, whereas data for pain threshold, pain intensity, pain-related fear and catastrophic worry were available for 84 participants. Therefore, degrees of freedom differ according to the outcome variable being examined. A Consolidated Standards of Reporting Trials (CONSORT) Flow Diagram of patient selection and dropout is presented in Figure 4.

3.2 | Descriptive participant characteristics

The final sample comprised 89 Flemish healthy children (50 boys and 39 girls) and one of their parents (70 mothers and 19 fathers). Due to technical issues, no socio-demographic data were recorded for one child (except child sex and age, which was also administered within the informed consents) and one parent. The children's age ranged from 8 years 10 months to 15 years 9 months ($M = 11.85$ years, $SD = 1.78$). Twenty-four (27.27%) children reported no pain in the last 2 weeks, and from the 64 children (72.73%) that did report to have experienced pain, 98.1% scored this pain as 'a little' to 'moderate'. Therefore, none of them was categorized as chronic pain. The age of the participating parents ranged from 32 to 55 years ($M = 43.38$, $SD = 5.10$). The overall majority of parents (94.32%) scored their own health as 'good' to 'excellent'. Most parents were married or cohabiting with their partner (79.8%) and were had higher education (beyond the age of 18) (71.9%). Demographic data for the experimental and control group are presented in Table 1.

Independent *t*-tests for the baseline assessments revealed that girls reported significantly more anticipated pain-related fear ($M_{girls} = 1.44$, $SD = 1.02$) and catastrophizing thoughts ($M_{girls} = 3.77$, $SD = 1.80$) at baseline compared to boys (respectively $M_{boys} = 1.00$, $SD = 0.81$, $t_{87} = -2.19$, $p = .032$; $M_{boys} = 3.07$, $SD = 1.48$, $t_{87} = -2.00$, $p = .048$). Girls and boys did not differ with regard to baseline anticipated pain intensity or pain knowledge. Further, no differences were found between the groups (video versus. no video) in terms of baseline anticipated pain intensity, pain-related fear and catastrophizing thoughts, nor for baseline pain knowledge.

3.3 | Correlation analyses

Means, SDs and Pearson correlation coefficients for all child data are presented in Table 2. The age of the children was significantly positively associated with their pain knowledge at baseline ($p = .003$) and just before the pain task ($p = .016$). Looking at associations between baseline

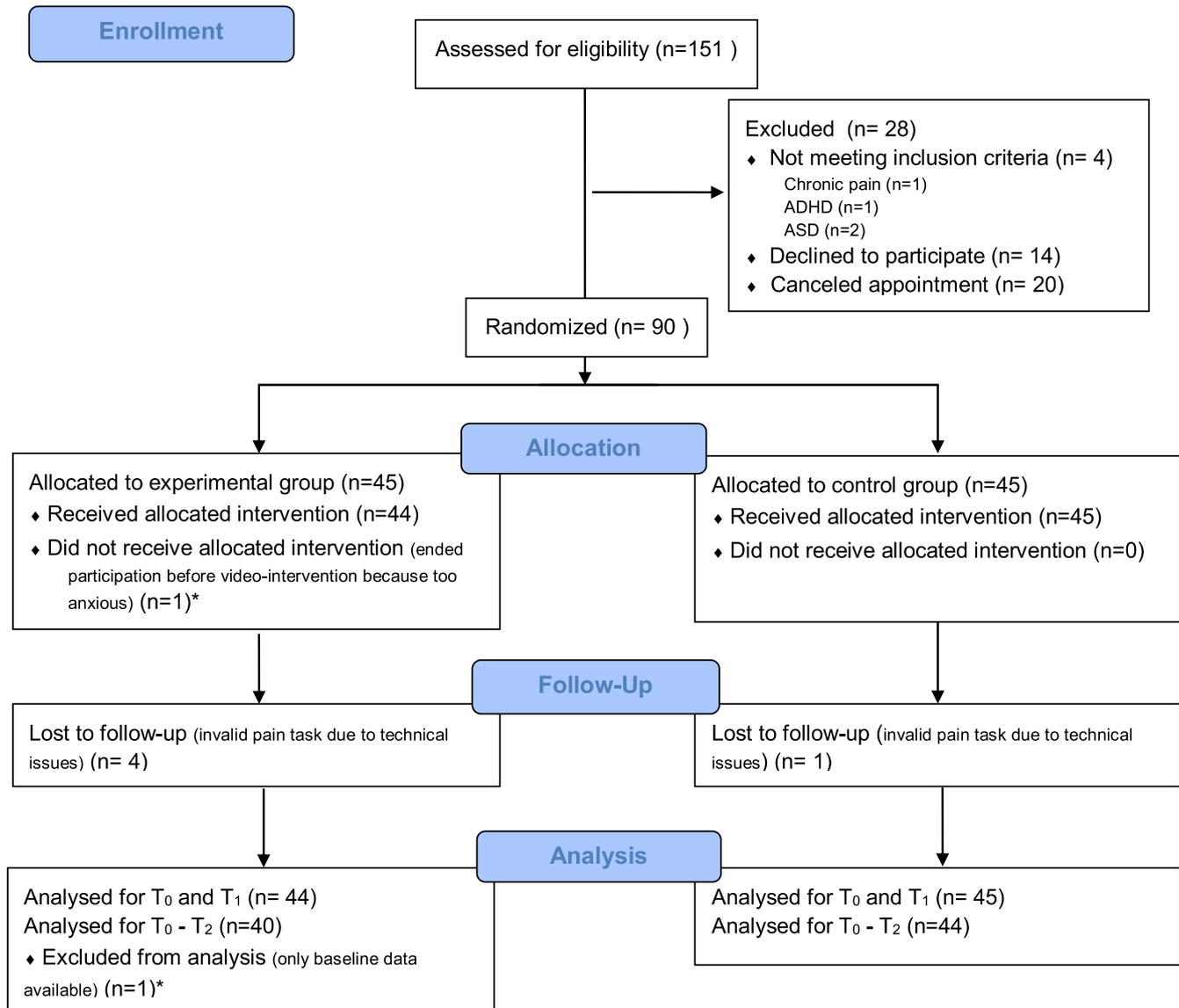


FIGURE 4 CONSORT Flow Diagram of participants through the study. T_0 = baseline upon the start of the experiment; T_1 = after the video intervention, upon the start of the heat pain task; T_2 = immediately after the heat pain task. Note that one participant stopped participation immediately after baseline measures and was, therefore, excluded from the study analyses, and that five participants (allocated to experimental group ($n = 4$) and control group ($n = 1$)) did not provide data for pain threshold and post-heat pain task measures

variables, correlation analyses showed that anticipated pain intensity, pain-related fear and catastrophic worry were all significantly positively correlated with each other (all $p < .05$). Similarly, experienced pain intensity, pain-related fear and catastrophic worry assessments were all significantly positively correlated with each other (all $p < .05$). Of further interest for this study, baseline pain knowledge was not significantly associated with any of the other baseline variables, but did show a significant negative association with experienced catastrophic worry about pain during the heat pain task ($p = .013$). Pain threshold was significantly negatively correlated with baseline anticipated ($p = .003$) and experienced ($p = .004$) pain-related fear and baseline anticipated ($p = .008$) and experienced ($p = .044$) catastrophic worry, and

significantly positively correlated with pain knowledge as assessed immediately after the video intervention ($p = .034$).

3.4 | Impact of the PNE4Kids-based video intervention upon pain knowledge

Regression analysis (see Table 3) demonstrated a significant main effect of baseline pain knowledge and the experimental intervention on pain knowledge measured just before the heat pain task (both $p < .001$), indicating that prior pain knowledge was associated with pain knowledge following video observation and that pain knowledge was higher amongst children who had watched the PNE-based video. No other main effects

TABLE 1 Descriptive participant characteristics

Characteristic		EG (<i>n</i> = 44)	CG (<i>n</i> = 45)
		<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)
Child's age in years		12.02 (1.87)	11.71 (1.71)
Parent's age in years		43.44 (4.96)	43.31 (5.30)
		<i>N</i> (%)	<i>N</i> (%)
Child's sex	Girl	20 (45.45%)	19 (42.22%)
	Boy	24 (54.55%)	26 (57.78%)
Parent's sex	Mother	32 (72.73%)	38 (84.44%)
	Father	12 (27.27%)	7 (15.56%)
Child's nationality	Belgian	43 (100%)	45 (100%)
	Other	0 (0%)	0 (0%)
Child's pain in the last 2 weeks	Yes	32 (72.73%)	32 (72.73%)
	No	12 (27.27%)	12 (27.27%)
Child's pain intensity last 2 weeks	No pain	12 (27.27%)	12 (27.27%)
	Little bit pain	8 (18.18%)	11 (25%)
	Moderate pain	21 (47.73%)	17 (38.64%)
	Much pain	3 (6.82%)	4 (9.09%)
	Very much pain	0 (0%)	0 (0%)
Health status of parent	Excellent	7 (16.28%)	7 (15.56%)
	Very good	14 (32.56%)	20 (44.44%)
	Good	18 (41.86%)	17 (37.78%)
	Moderate	4 (9.30%)	1 (2.22%)
	Poor	0 (0%)	0 (0%)
Family status	Married or cohabiting	33 (76.74%)	38 (84.44%)
	Divorced	1 (2.33%)	6 (13.33%)
	Widow(er)	0 (0%)	0 (0%)
	Single parent or unmarried	7 (16.28%)	0 (0%)
	Newly assembled family	2 (4.65%)	1 (2.22%)
Education level of parent	Primary education (≤ 12 yo)	0 (0%)	0 (0%)
	Lower secondary education (≤ 14 yo)	0 (0%)	0 (0%)
	Higher secondary education (≤ 18 yo)	12 (27.91%)	12 (26.67%)
	Higher education (bachelor or master)	31 (72.09%)	33 (73.33%)
Occupation of parent	Housewife/househusband	0 (0%)	2 (4.44%)
	Labourer	6 (13.95%)	2 (4.44%)
	Employee	24 (55.91%)	29 (64.44%)
	Liberal profession	2 (4.65%)	2 (4.44%)
	Self-employed	4 (9.30%)	2 (4.44%)
	Managerial position	3 (6.98%)	1 (2.22%)
	Unemployed	0 (0%)	0 (0%)
	Other	4 (9.30%)	7 (15.56%)

Abbreviations: CC, control group; EG, experimental group.

were observed. However, a significant condition \times child's age interaction effect was observed on pain knowledge, indicating that the impact of the experimental condition (i.e. video versus. no video) upon pain knowledge measured after the video

intervention is dependent upon the age of the child ($p = .035$). No other significant interactions were observed. To illustrate the pattern reflected in the statistically significant condition \times age interaction, regression lines were plotted for younger

TABLE 2 Number of valid cases (*N*), means (*M*), standard deviations (*SD*) and Pearson correlation coefficients for all child data

	<i>N</i>	<i>M</i>	<i>SD</i>	Range	2	3	4	5	6	7	8	9	10
1. Child age	89	11.85	1.78	8–15	0.19	0.06	0.09	0.31 ^{**}	0.26 [*]	0.19	0.06	0.07	0.07
2. Baseline pain (T0)	89	2.08	0.81	0–5	-	0.52 ^{**}	0.48 ^{**}	0.09	0.12	-0.13	0.25 [*]	0.15	0.18
3. Baseline fear (T0)	89	1.19	0.93	0–4	-	-	0.54 ^{**}	-0.03	0.01	-0.32 ^{**}	0.25 [*]	0.33 ^{**}	0.25 [*]
4. Baseline catastrophic worry (T0)	89	3.38	1.65	0–10	-	-	-	-0.17	-0.08	-0.29 ^{**}	0.21	0.31 ^{**}	0.47 ^{**}
5. Pain knowledge (T0)	89	21.72	3.23	0–32	-	-	-	-	0.62 ^{**}	0.21	-0.07	-0.15	-0.27 [*]
6. Pain knowledge (T1)	87	23.08	3.62	0–32	-	-	-	-	-	0.23 [*]	-0.02	-0.07	-0.02
7. Pain threshold	89	46.40	3.13	42–54	-	-	-	-	-	-	-0.05	-0.31 ^{**}	-0.22 [*]
8. Experienced pain (T2)	84	1.31	0.98	0–5	-	-	-	-	-	-	-	0.59 ^{**}	0.61 ^{**}
9. Experienced fear (T2)	84	0.67	0.84	0–4	-	-	-	-	-	-	-	-	0.52 ^{**}
10. Experienced catastrophic worry (T2)	84	1.85	1.74	0–10	-	-	-	-	-	-	-	-	-

Note: T0 = baseline; T1 = just before pain task; T2 = immediately after pain task

p* < .05, *p* < .01

TABLE 3 Results of hierarchical regression analyses investigating the effect of a PNE4Kids-based video intervention upon pain intensity, pain-related fear, state catastrophic worry, pain threshold and pain knowledge and the moderating role of children's demographic (i.e. sex and age) and psychological (i.e. baseline pain knowledge and anticipated pain intensity, pain-related fear and state catastrophic worry) characteristics

Criterion variable	Step	Predictor	β	ΔR^2	Adjusted R^2
Pain knowledge	1	Sex	-0.05	0.08*	0.06
		Age	0.21		
	2	Baseline pain	-0.06	0.32***	0.35
		Baseline fear	0.08		
		Baseline catastrophic worry	0.08		
		Baseline pain knowledge	0.60***		
		Condition	0.43***	0.17***	
	4	Condition x sex	-0.01	0.03	0.52
		Condition x age	-0.26*		
		Condition x baseline pain	-0.01		
		Condition x baseline fear	0.07		
		Condition x baseline catastrophic worry	-0.04		
		Condition x base pain knowledge	0.13		
Pain threshold	1	Sex	-0.01	0.11**	0.09
		Age	0.13		
	2	Baseline pain	-0.11	0.10*	0.16
		Baseline fear	-0.22		
		Baseline catastrophic worry	-0.08		
		Baseline pain knowledge	0.01		
	3	Condition	0.35*	0.02	0.16
		Condition x sex	-0.43*	0.07	
	4	Condition x age	0.15		0.18
		Condition x baseline pain	-0.00		
		Condition x baseline fear	0.12		
		Condition x baseline catastrophic worry	0.02		
		Condition x base pain knowledge	0.17		
Experienced pain	1	Sex	-0.02	0.00	-0.02
		Age	0.06		
	2	Baseline pain	0.39	0.09	0.02
		Baseline fear	0.16		
		Baseline catastrophic worry	-0.05		
		Baseline pain knowledge	-0.13		
		Condition	-0.06	0.01	
	4	Condition x sex	-0.08	0.05	-0.01
		Condition x age	0.06		
		Condition x baseline pain	-0.33		
		Condition x baseline fear	-0.04		
		Condition x baseline catastrophic worry	0.11		
		Condition x base pain knowledge	0.07		

(Continues)

TABLE 3 (Continued)

Criterion variable	Step	Predictor	β	ΔR^2	Adjusted R^2
Experienced fear	1	Sex	-0.03	0.01	-0.02
		Age	0.13		
	2	Baseline pain	0.22	0.15*	0.09
		Baseline fear	0.12		
		Baseline catastrophic worry	0.24		
		Baseline pain knowledge	0.12		
	3	Condition	-0.04	0.01	0.09
	4	Condition x sex	-0.07	0.08	0.11
		Condition x age	-0.00		
		Condition x baseline pain	-0.34		
		Condition x baseline fear	0.11		
		Condition x baseline catastrophic worry	-0.08		
Condition x base pain knowledge		-0.27			
Experienced catastrophic worry	1	Sex	-0.18	0.01	-0.02
		Age	0.08		
	2	Baseline pain	0.10	0.27***	0.22
		Baseline fear	-0.02		
		Baseline catastrophic worry	0.35		
		Baseline pain knowledge	-0.19		
	3	Condition	-0.07	0.00	0.21
	4	Condition x sex	0.12	0.03	0.18
		Condition x age	0.04		
		Condition x baseline pain	-0.23		
		Condition x baseline fear	0.10		
		Condition x baseline catastrophic worry	0.15		
Condition x base pain knowledge		0.03			

Note: Standardized regression coefficients (β) from the last step of the analyses are displayed.

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

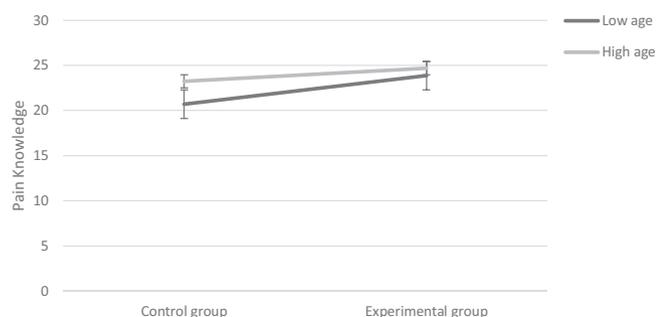


FIGURE 5 Mean child pain knowledge as a function the experimental condition and low ($-1SD$ below the mean) and high ($+1SD$ above the mean) child age (Low age: $\beta = 0.44$, $p = .003$; High age: $\beta = 0.20$, ns)

($-1SD$ above the mean) and older ($+1SD$ below the mean) children (see Figure 5). Significance tests for both slopes showed that the slope for younger children was significant ($p = .003$), indicating that for younger children the video intervention contributed, in comparison with the control condition, to higher levels of pain knowledge. The video intervention had no impact upon pain knowledge for older children.

3.5 | Impact of the PNE4Kids-based video intervention upon pain threshold

The analysis with pain threshold as dependent variable (see Table 3) revealed a significant main effect of the

experimental intervention ($p = .016$), indicating that children in the experimental group presented a significantly higher heat pain threshold compared to the control group. No other main effects were observed. However, interaction analysis demonstrated a significant condition \times child's sex interaction, indicating that the impact of the experimental condition (i.e. video vs. no video) upon the pain threshold is dependent upon the sex of the child ($p = .024$). To illustrate the pattern reflected in this statistically significant interaction, we plotted separate regression lines for boys and girls (see Figure 6). Significance tests for both slopes showed that the slope for boys was significant ($p = .048$), indicating that the video intervention resulted in higher pain thresholds compared to the control group for boys, but not for girls.

3.6 | Impact of the PNE4Kids-based video intervention upon pain intensity, pain-related fear and catastrophic worry about pain

Analysis with pain intensity, pain-related fear and state catastrophic worry experienced during the heat pain task as dependent variables revealed no significant main effect of the experimental intervention. Further, no other main or interaction effects were observed for these outcome measures (see Table 3).

4 | DISCUSSION

This study examined the effect of a brief pain educational video intervention on pain knowledge, pain threshold, pain intensity, pain-related fear and state catastrophic worry in healthy children undergoing an experimental pain task compared to a control group of healthy children undergoing the same experimental pain task without watching any video. Furthermore, the study explored which children are likely to benefit more or less by this video intervention depending upon a number of demographic (i.e. sex and age)

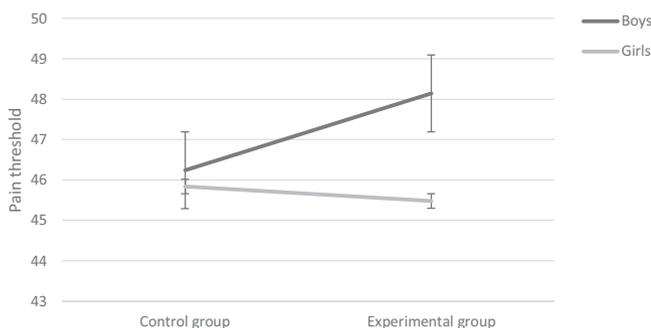


FIGURE 6 Mean child pain threshold as a function the experimental condition and child's sex (boys: $\beta = 0.29$, $p = .048$; Girls: $\beta = -0.06$, ns)

and psychological (i.e. baseline pain knowledge and anticipated pain intensity, pain-related fear and state catastrophic worry) characteristics. Results indicated no main effects of the video on experienced pain intensity, pain-related fear and state catastrophic worry during the pain task. However, pain knowledge and pain threshold were significantly higher in children who watched the video compared to the control group. Furthermore, moderation analyses showed that the experimental group demonstrated, compared to the control group, higher levels of pain knowledge amongst younger (not older) children and higher pain thresholds amongst boys (not girls).

The observed impact of the PNE4Kids-based video on children's pain knowledge is consistent with existing literature on PNE-based interventions in clinical and non-clinical paediatric and adolescent samples (see e.g. Abram et al., 2007; Cox et al., 2017; Louw et al., 2018). Yet, current findings extend previous ones by demonstrating that the PNE4Kids-based video intervention did not only beneficially impact children's pain knowledge but also children's pain threshold. Indeed, the current findings are the first to provide preliminary evidence that heat pain thresholds in healthy children are higher after re-conceptualizing 'pain' by a PNE4Kids-based video intervention compared to a control group who did not watch the video. These results are in line with previous study findings in adult (Bodes Pardo et al., 2018; Louw A Pt et al., 2019) and paediatric (Pas et al., 2020) chronic pain populations demonstrating higher pressure pain thresholds following pain educational interventions.

The current findings suggest that a brief PNE4Kids-based video as a method for providing pain education partially results in more favourable pain-related outcomes. Within the video, advantages of existing PNE delivery methods for children (e.g. face-to-face sessions (Pas et al., 2018), video's (Heathcote et al., 2019; Pate, et al., 2020), PowerPoint presentations (Cox et al., 2017; Louw et al., 2018)) were combined, as the video embodied hands-on interactive learning, online but face-to-face education, metaphors, images and storytelling in a time efficient way. However, caution is needed when drawing conclusions on the effectiveness of the current PNE-based intervention, as findings of this study also showed the impact of the intervention being dependent upon child socio-demographic variables (i.e. age and sex). Furthermore, beneficial effects observed for pain knowledge and pain threshold did not extend to experienced pain intensity, pain-related fear and catastrophic worry.

Findings of moderation analyses highlight the importance of assessing individual differences in understanding the observed effects of the video intervention. Particularly, beneficial effects of the PNE4Kids-based video intervention upon pain knowledge were only observed amongst younger children and higher pain thresholds were only observed for boys. The finding that the impact of the PNE4Kids-based

video was only beneficial for younger children's pain knowledge may suggest that the content of the video needs more attunement to the age of the children, as PNE4Kids (Pas et al., 2018) was developed for children aged 6 to 12 while the sample of this study was 8 to 15 years old. In addition, older children might have had slightly more knowledge about pain from the start, which was supported by the positive association found between the children's age and baseline pain knowledge. Therefore, older children might have had less margin to grow in terms of pain knowledge than younger children. However, the demonstrated age effect is in line with earlier findings amongst adults, showing that age is significantly associated with changes in pain knowledge following a PNE intervention, with for each 10 years of increasing age a 0.5 point smaller improvement in pain knowledge (Pate et al., 2019).

Observed findings regarding the moderating role of child sex may be accounted for by gender-role expectations and socialization processes. Indeed, boys and girls are socialized along gender norms for how to respond to pain from an early age. It is suggested that boys are taught to be stoic, to tolerate pain and to endure painful experiences, while girls are more socialized to be sensitive and careful, and to verbalize hurt or discomfort (Myers et al., 2003). Possibly, watching the PNE4Kids-based video might have triggered expectations of pain endurance more in boys and not in girls. Findings among adults with chronic pain have indicated comparable results indicating that men are more likely than women to expect recovery following pain education (Mittinty et al., 2018). Alternatively, the sex of the experimenter in the current trial might have played a role as well. Indeed, evidence shows that adult subjects tolerate pain longer when tested by an experimenter of the opposite sex (Kállai et al., 2004; Levine & De Simone, 1991). While, in this study, the experimenters (i.e. almost always female) who determined the child's pain threshold were the same in both groups (i.e. intervention and control group), the person talking to the children in the video was female, which may partly explain the condition x child's sex interaction effect upon children's pain threshold. Yet, this rationale is only tentative and caution is needed in extending the findings of the mentioned studies (Kállai et al., 2004; Levine & De Simone, 1991) to this study, which included children instead of adults and almost exclusively female experimenters. Overall, the above explanations require further empirical inquiry.

The current findings demonstrating no impact of the PNE4Kids-based intervention upon experienced pain intensity, pain-related fear and catastrophic worry contradict earlier findings amongst adult chronic pain patients (Gallagher et al., 2013; Louw et al., 2011, 2016; Meeus et al., 2010; Moseley et al., 2004; Moseley, 2003; Ryan et al., 2010; Van Oosterwijck et al., 2011)). A number of tentative explanations may account for the observed null effects. First, the video

might have been insufficiently translated to the specific situation (i.e. experimental heat stimulation). Children learned about the biopsychosocial mechanisms of pain through the PNE4Kids-based video, but the provided examples of 'misleading the officer' and coping techniques were not directly linked to the heat stimuli they would subsequently receive. Next, while we tried to make the video as interactive as possible, the video was not attuned to the specific needs of the individual child. Face-to-face PNE sessions might have been more effective here, as they create the ability to directly respond to (non-)verbal patient cues and enable the opportunity to use certain communication skills (e.g. Socratic-style dialogue) (Nijs et al., 2020). In addition, PNE aims to shift one's conceptualization of pain (Moseley & Butler, 2015) and therefore needs to challenge one's existing knowledge and knowledge structures, which might be more feasible within face-to-face interactive sessions. Furthermore, this trial investigated pain-related outcomes in healthy children without complaints of recurrent or chronic pain. As literature indicates that pain catastrophizing in healthy individuals is generally quite low compared to individuals with persistent pain (Sullivan et al., 1998, 2005; Sullivan & Stanish, 2003) and that pain catastrophizing is reliably associated with pain reports during experimental pain in healthy pain-free subjects (Galambos et al., 2019), the healthy state of the participants in this study may have reduced the likelihood of finding effects from the video intervention. Importantly, yet a change towards adaptive coping behaviour appears to have occurred as the experimental group demonstrated higher pain thresholds compared to the control group. Finally, as experienced pain intensity, pain-related fear and catastrophic worry were measured after the pain task, including repeated heat stimuli, the heat stimuli's threat value might have dropped and habituation might have occurred (Kleinböhl et al., 2006).

A number of limitations must be taken into account, each providing directions for future research. First, the study sample consisted of healthy school children participating in a standardized pain task within a safe experimental environment. Participants were informed about the safety of the Medoc software, with a limitation of the maximum temperature of heat stimulation to 54°C. In addition, children who were highly anxious about the pain stimuli, most likely declined to participate, possibly creating a bias. Second, as the control group did not receive any intervention and therefore received no/less attention from the experimenter, a placebo effect could not be excluded. Last, study findings were based on cross-sectional data. Prospective longitudinal research is warranted to determine whether watching a PNE4Kids-based video might work preventively in the development of chronic pain problems.

Despite its limitations, this study adds to our understanding of the impact of a PNE4Kids-based video intervention in a sample of 8- to 15-year-old healthy children undergoing an

experimental pain task. Examining the impact of pain educational interventions within a non-clinical setting is deemed particularly important given that adaptive pain coping strategies likely play an important role in preventing the development and maintenance of future maladaptive pain-related behaviour (Patterson & Ware, 1988; Rabbitts et al., 2017; Simons et al., 2008). Further, study findings provide preliminary evidence of baseline and demographic (i.e. age and sex) characteristics explaining differences in the effect of such video in pain knowledge and pain-related experiences during experimental pain. Although boys and girls seem to experience painful experiences similarly and should, therefore, be approached similarly within pain educational interventions, this pain educational video targeting healthy children seems to be most beneficial for younger children and boys in particular. Further investigations into mechanisms underlying differential effects of pain educational intervention are warranted to aim for effective preventive pain management strategies in healthy children. In addition, further investigation is needed to determine whether more beneficial outcomes (e.g. less experienced pain intensity) can be found in clinical (i.e. non-experimental) situations and in children with persistent or recurring pain problems.

ACKNOWLEDGEMENTS

A sincere thanks goes to the Master of Science students Experimental and Clinical Health Psychology of Ghent University (Eline Buysse, Elie Van Oerle, Elise Hoirelbeke, Silke Wintein, Laurence Luteijn, Camille Laethem, Merlijn Paelinck, Julie Hollevoet, Ester Goeminne, Linde Colman) for their help with the data collection and data input.

CONFLICT OF INTEREST

Grant support for Emma Rheel was provided by a Chair funded by the Berekuyt Academy/European College for Decongestive Lymphatic Therapy, the Netherlands and awarded to the Vrije Universiteit Brussel, Belgium. K. Ickmans and A. Malfliet are postdoctoral research fellows, partly funded by the Research Foundation – Flanders (FWO). None of these sponsors played a role in the (1) study design, (2) collection, analysis and interpretation of data, (3) writing of the report, (4) decision to submit the paper for publication. Besides, all authors declare that no conflicts of interest exist.

AUTHOR CONTRIBUTIONS

Emma Rheel was responsible for the study design, data collection, data input, data analysis and interpretation of study findings, as well as the writing of the drafts and final version of the manuscript. Kelly Ickmans provided thoughtful suggestions on the design of the study, provided feedback on the interpretation of study findings and revised the manuscript critically for important intellectual content. Aline Wauters was involved in the study design, data collection and data

input, and revised the manuscript critically for important intellectual content. Dimitri M.L. Van Ryckeghem provided thoughtful suggestions on the design of the study and was responsible for the programming of the Medoc Neuro Sensory Analyser for the experimental heat pain task. Further, he revised the manuscript critically for important intellectual content. Tine Vervoort was involved in the study design and provided thoughtful suggestions on interpretation of findings and actively contributed to writing and editing of the manuscript. All authors discussed the results, commented on the manuscript and gave final approval of the version to be published prior to submission.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Rheel, E., Ickmans, K., Wauters, A., Van Ryckeghem, D. M. L., Malfliet, A., & Vervoort, T. (2021). The effect of a pain educational video intervention upon child pain-related outcomes: A randomized controlled study. *European Journal of Pain*, *25*, 2094–2111. <https://doi.org/10.1002/ejp.1822>