Research Article

Investigating the effects of cognitive interventions on reducing pain intensity and modifying heart rate and oxygen saturation level

Maryam Farrokhnia*[1], Jalil Fathabadi[1], Shahriar Shahidi[1]

Received: 10/05/2010 Revised: 04/30/2011 Accepted: 06/21/2011

1. Dept. of Psychology, School of Psychology and Educational Sciences, Shahid Beheshti University, Tehran, Iran

Journal of Jahrom University of Medical Sciences, Vol. 9, No. 3, Fall 2011

Abstract:

Introduction:
In the present study, we investigated the efficacy of cognitive interventions in reducing reported pain intensity as well as modifying heart rate or oxygen saturation level in children with cancer during lumbar puncture or intrathecal injection. Moreover, we studied the relationship between the reported pain intensity and changes in heart rate and oxygen saturation level resulting from lumbar puncture or intrathecal injection.

Material and Methods:
This is a clinical trial using a pretest-posttest design with control group. 41 child-parent pairs were selected and randomly assigned to two groups. The children were visited twice; on first visit, both groups received routine care. On second visit, the experiment group received cognitive interventions and the second group received routine care. Data were collected using a demographic questionnaire, Oucher's self-report pain intensity scale, and pulse oximeter. We used analysis of covariance and Pearson's correlation to analyze the data.

Results:
Our findings indicate that the interventions efficiently reduce reported pain intensity, lower heart rate and increase blood oxygen saturation level during lumbar puncture or intrathecal injection. We also found a significant positive correlation between reported pain intensity and changes in heart rate, and a significant negative relationship between reported pain intensity and changes in oxygen saturation level.

Conclusion:
Cognitive interventions are efficient for reducing reported pain intensity, lowering heart rate and increasing oxygen saturation level during lumbar puncture or intrathecal injection. We recommend cognitive interventions to be used during this painful procedure to manage pain and minimize physiologic changes resulting from lumbar puncture.

Keywords: Physiology, Pain, Heart Rate, Oxygen Saturation Level

Introduction:

Cancer is a painful, chronic disease (1). About half of children with cancer experience its associated pain during diagnosis of active therapeutic procedures (2, 3). Previous studies suggest that pain resulting from medical procedures and therapy is a greater challenge for these patients compared to the pain resulting from the disease itself (4, 5). Painful medical interventions constitute an inevitable reality that must be encountered from birth to death (6). This type of pain, however, must necessarily be fought against (7). Children with cancer undergo many painful medical procedures such as lumbar puncture – LP (8,

* Corresponding Author, Address: Number 11, Next to Aftab Building, Vahid Dastgerdi Street, Dr. Shariati Avenue, Tehran
Tel: 021 22227936 – 09113238332, Email: maryam.farrokhnia@gmail.com

9), which is particularly painful (10). Pain resulting from diagnostic and therapeutic procedures for cancer falls in the category of acute pains, which leads to somatic and autonomous responses such as profuse perspiration, elevated blood pressure, and increased heart rate, respiration rate and oxygen intake (11). There is sufficient data indicating that non-invasive measurement of heart rate and blood oxygenation via skin provides a valid indirect estimate of pain intensity. Heart rate is the most universally used biologic scale for quantifying pain in newborns and infants as it rises generally in response to invasive medical procedures. The level of hemoglobin oxygen saturation, as measured via skin, falls during painful procedures, such as lumbar puncture (12, 13). Heart rate has been repeatedly used as a physiologic sympathizer of acute pain intensity (14). Using the changes in base levels of physiologic parameters, e.g. heart rate or respiratory rate, we may deduce the presence or intensity of pain indirectly (15). Different studies have indicated the relationship between pain and physiological parameters. Tousignant-Laflamme et al investigated the relationship between heart rate and pain perception to find a significant correlation between heart rate and pain intensity and pain complaint (16). Moeltner et al studied the heart rate response to painful thermal stimuli and discovered that stimuli with greater intensity induce a greater elevation in mean heart rate (17). Studies dealing with postsurgical pain have used cardiovascular measurements to document pain and efficiency of psychological interventions. Patients who had received confrontational psychological training had lower blood pressure and heart rate compared to those who had not been trained (14).

Improving the survival rate of children suffering from cancer rests on using very aggressive therapy protocols. Despite these advancements, the children require extra support in order to be able to tolerate adverse effects, including pain, resulting from therapy (1). Pain is deleterious for children's health (18) and unless alleviated properly, it will bring about harmful physical and psychological outcomes (19). Simultaneous use of medical and non-medical approaches is the cornerstone of pediatric pain management (7). Non-medical interventions are used extensively for pain management (20). Among these, cognitive-behavioral interventions meet the criteria of acute pain management in pediatrics, as supported by experimental evidence (21). Previous studies indicate that using distraction as a cognitive approach diminished pain (6). Distracting the attention appropriately, when the child's attention is completely absorbed into an activity or subject unrelated to pain, is an active process by which nervous responses resulting from tissue injury are suppressed (22). Another principal cognitive intervention is to provide the child with information about pain and simple coping skills, based on the child's age. When a child is properly aware of what is going to happen to them and the associated feelings, he/she will have an improved understanding of pain, gain better control over it and diminish his/her discomfort and pain (14). Preparing the child and his/her family is an important measure for reducing pain in procedures using needle (23).

Considering the deleterious effects of pain on children's health, and the role of acute pain in modifying physiological parameters such as heart rate and blood oxygen saturation level, as well as the shortage of Iranian studies dealing with psychological management of acute pain during LP, the question rises whether non-medical interventions (e.g. preparation and distraction) may reduce acute pain and its ensuing physiological changes. The purpose of the present study is to investigate the effects of cognitive interventions on reported pain intensity, heart rate and oxygen saturation level of children with cancer during lumbar puncture or intrathecal injection (LP/IT), as well as to study the relationship between pain intensity reported by the child and changes in heart rate or blood oxygen saturation level during LP/IT.

Material and Methods:

After acquisition of necessary permits, the study was conducted in two healthcare centers of Mofid Pediatric Hopsital and Mahak Hospital facilities. Our study population consisted of all children with different types of cancer (blood cancer, lymphoma, central nervous system tumors or musculoskeletal tumors) who referred to Mahak Hospital facilities (affiliated with the charity organization for supporting cancer children) or Mofid Pediatric Teaching Hospital in Tehran for the purpose of lumbar puncture or intrathecal injection. The children were randomly selected for both groups in terms of their cancer type or number of LP/IT. Once the eligible children (in terms of age) were identified, the researchers were introduced to the parents and explained the study and its objectives to them. Parents who agreed for participation in the study expressed their written informed consent. The parents were also asked to consult with the children for participation in the study. We used objective sampling and calculated a sample size of 41 children for our study. Each child-parent pair was randomly assigned to either the experiment or the control groups. Our participants consisted of 21 (51.2%) girls and 20 (48.8%) boys. 21 child-parent pairs were assigned to the experiment group, and 20 pairs to the control group. The mean age of children was 78.20 months (with standard deviation of 15.884 months) which is equal to six years and half. The inclusion criteria were 5-8 years of age, cancer diagnosis, referral to the healthcare center for LP/IT, lack of any previous psychological intervention for pain management, lack of other chronic systemic diseases, and using topical anesthetic cream prior to the procedure. The exclusion criteria were parent's presence during LP/IT, use of systemic analgesics such as midazolam (outside standard healthcare routine), and congenital disorders such as heart failure, asthma and diabetes due to the possibility of their affecting the physiological parameters. Our clinical trial used a pretest-posttest design with control group. The experimental intervention (parent's briefing and preparation booklet, distracting the child during LP/IT through displaying a cartoon, solving a maze or coloring a short story coloring book) was applied only to the experiment group so that we could investigate the effect of these cognitive interventions on reported pain intensity, heart rate and blood oxygen saturation level of children who underwent the painful procedure of LP/IT.

Data collection tools consisted of a questionnaire developed by the authors to collect demographic characteristics (age, sex, diagnosis, etc) and inclusion criteria, Oucher's self-report pain scale, and pulse oximeter. Oucher's scale is a poster comprised of two scales: for older children, it uses a 0-10 or 0-100 scale, and for younger children, it uses a pictographic scale with six pictures on the right and the numbers 0-10 on the left. On a 0-10 scale, the number uttered by the child designates his/her pain score. On the pictogram, the picture selected by the child must be translated to its numerical even value, ranging from 0-10: the lowest picture = 0; second picture = 2; third picture = 4; fourth picture = 6; fifth picture = 8; and sixth picture = 10. There are currently 5 versions of Oucher's scale. Due to the unknown reliability of the Asian scale, and the facial similarity of Oucher's Spanish version to Iranian children, as well as the known reliability of this version, we used the Spanish version in our study. Content validity of the Spanish version is equal to 0.65 using Kendall's coefficient of concordance and $p < 0.001$. Beyer et al reported the reliability of Oucher's scale to be equal to 0.912 for the pictogram and 0.984 for the numerical scale, assuming $p = 0.000$ (24).

Pulse oximeter is a device for constant monitoring of heart rate and arterial oxygen saturation level. It measures hemoglobin saturation with oxygen, which is normally between 95% and 100%. Measurements are made by placing a sensor on a vascular bed with pulsating arterioles. A monitor then displays heart rate and oxygen saturation level (25).

In order to collect data, the researchers attended the healthcare centers on a daily basis from February 7, 2010 to July 6, 2010. After obtaining permission for the study from Shahid Beheshti University of Medical Sciences and authorities of the healthcare centers, as well as informed consent of the child and the caregiver, we initially gathered the data pertaining to demographic information and inclusion criteria. The children were individually visited twice. On first visit, both groups received the routine care – topical cream before procedure and a prize after procedure. At the end of the first visit, a briefing booklet was submitted to parents, containing information regarding pediatric pain management and a story about LP/IT. The parents were required to study the information, read the story out loud for the child and have him/her color the schemes during the interval between the first and second visits. On second visit, children in the experiment group were provided with distraction measures, i.e. a maze (in the waiting hall prior to painful procedure) and a cartoon (during painful procedure), while children in the control group received the routine care. On each visit, pain intensity was measured 3-5 minutes after procedure. Physiological measurements were made twice (prior to procedure and on needle entry on second visit) using pulse oximetry. Data collected from pretest and posttest of the experiment and control groups were analyzed using analysis of covariance. We used Pearson's correlation to study the relationship between pain intensity and physiological changes. Our ethical considerations included provision of comprehensive information to the parent about the aim of the study and the parents and children's responsibilities, parents' deliberate consent for participation in the study expressed in written, children's consent for participation in the study obtained with parents' help, and parents and children's freedom to quit the study at any point.

Results:

The results of inferential analysis of data are presented in tables 1, 2, and 3. Distribution of means and standard deviations of variables (table 1) indicates that reported pain intensity diminished significantly for the experiment group. Moreover, the two groups were significantly different in terms of heart rate and blood oxygen saturation level.

Our findings indicate that the impact of cognitive interventions is significant. In other words, the difference in heart rate and oxygen saturation of the two groups during LP/IT is statistically significant ($p < 0.0001$). The findings in tables 1 and 2 show that the interventions were efficient in reducing repoted pain intensity, lowering heart rate and improving oxygen saturation during LP/IT.

The results of Pearson's correlation (table 3) indicate a significant positive correlation between reported pain intensity and changes in heart rate, as well as a significant negative correlation between reported pain intensity and changes in oxygen saturation level at P<0.0001.

Table 1: Distribution of mean and standard deviation of variables of reported pain intensity, heart rate and oxygen saturation level on posttest

Variables	Experiment Group	Control Group
	Mean (Standard Deviation)	Mean (Standard Deviation)
Pain Intensity	2.00 (2.449)	4.40 (2.393)
Heart Rate	128.86 (13.983)	149.15 (19.653)
Oxygen Saturation level	96.76 (1.411)	93.50 (2.646)

Table 2: Summary of analysis of covariance of variables of pain intensity and changes in heart rate and oxygen saturation level during LP/IT

Group Effect for Variables	Sum of squares	Degree of freedom	Mean of squares	F	Level of significance
Reported Pain Intensity	89.179	1	89.179	30.412	0.000
Heart Rate	806.028	1	806.028	10.115	0.003
Oxygen Saturation Level	72.487	1	72.487	18.539	0.000

Table 3: Summary of correlation coefficients for study variables

Study Variables	Correlation Coefficient	Level of Significance
Reported Pain Intensity and Changes in Heart Rate	0.797*	0.000
Reported Pain Intensity and Changes in Oxygen Saturation Level	-0.0598*	0.000

* Correlation is significant at p < 0.01 (2 domains).

Conclusion:

The present study investigates the impact of cognitive interventions (child distraction and preparation of child and parent) on reported pain intensity and changes in heart rate and oxygen saturation level of children with cancer who undergo lumbar puncture or intrathecal injection. There is solid, copious study literature supporting the efficiency of cognitive interventions (particularly the distraction strategy) in reducing pain for procedures involving needle use. Since children are more susceptible to suggestion and confide in others more than adults, they usually respond well to psychological strategies which distract their attention from pain or reframe their pain. We know that anticipating a horrifying event is often more agonizing than the event itself. There is extensive research indicating that appropriate preparation of an individual, considerably diminishes the pain resulting from the expected noxious stimulus. It is well established that preparing a child for an impending procedure improves anxiety significantly and thus reduces the pain (26).

Cohen et al used distraction in the form of game and managed to modify physiological and behavioral parameters resulting from newborns' pain (27). Richards et al conducted a study on the effect of music therapy on perception and manifestations of pain and anxiety and patient satisfaction to discover that pain, anxiety, blood pressure and heart rate diminished in the experiment group (28). Prabhakar et al used audio and audio-visual distraction techniques to manage anxiety in pediatric dentistry; they concluded that there is a significant difference between the control and audio-visual distraction groups in terms of heart rate and oxygen saturation level (29). Our findings regarding the efficiency of cognitive interventions in reducing reported pain intensity and changing heart rate and oxygen saturation level are consistent with those of the mentioned studies. In order to justify these findings, it must be noted that attention is defined as “the mechanism for separating desired and undesired information” (30) and it is the primary mechanism by which a painful stimulus achieves awareness (6). The pain relieving property of distraction may be accounted for by the cognitive theory of limited attention capacity. Reception of a noxious stimulus is considered a non-automatic process requiring effort, thus necessitating attention for discovering it (30). It is presumed that pain perception is not a fully automatic process and involves cognitive processing. If the child’s attention for attention is limited or another activity competes sufficiently with the painful stimulus, then theory dictates that perception of the noxious stimulus as painful shall be modified (31). It appears that cognitive strategies which divert an individual’s attention from harmful and threatening situations towards neutral or pleasant ones may prevent the painful stimulus to attain awareness (32). Consistent with this theory, mazes and cartoons offered to children managed to distract them before and during procedure, thereby reducing reported pain intensity.

Different studies demonstrate the relationship between pain and physiological parameters (16). In response to pain, heart rate elevates and blood oxygen saturation level falls (33). Our findings corroborate this statement and are in line with findings of Turk and Melzack (14), Tousignant-Laflamme et al (16) and Moeltner et al (17). To account for these findings, we may point out the role of the autonomous nervous system in making physiological modifications resulting from painful stimuli. Danger and threat signals are transmitted to hypothalamus and travel along the spinal cord through sympathetic pathways. Ultimately, some nerve fibers activate certain organs, such as those inducing stimulation. These organs increase their function in order to prepare for fighting or escaping. Simultaneously, the activities which are not required for response will decline. Thus, a danger or threat signal elevates heart rate and blood pressure, increases oxygen intake and perspiration, dilates pupils and boosts glycogen metabolism in muscles (34). Children undergoing painful medical procedures manifest similar responses, indicating mental pressure. Consequently, children’s pain and discomfort may be evaluated as reflected in changes of physiological parameters (1, 15).

Anxiety and discomfort resulting from acute pain boosts the release of corticosteroids, glucagon, catecholamines, and growth hormone. These changes increase heart rate and pumping power (thus increasing the need for oxygen) on one hand, and constrict vessels (thus compromising tissue perfusion and oxygenation) on the other. The change in pulmonary ventilation also contributes to development or aggravation of hypoxemia in pain. This situation results in reduced oxygen saturation level (35). Considering the relationship between acute pain and blood oxygen saturation level, cognitive interventions may improve tissue oxygenation and prevent or alleviate hypoxemia (table 3). Preparing or distracting the child may reduce the chemical and physiological changes resulting from lumbar puncture or intrathecal injection through diminishing his/her anxiety and discomfort.

Considering the efficiency of cognitive interventions in reducing reported pain intensity and heart rate and increasing oxygen saturation level in children with cancer undergoing lumbar puncture or intratechal injection, they may be recommended for this painful procedure. In general, since these interventions improve acute pain, they may be modified or amended to be used for comforting pain and anxiety in children who suffer from other acute or chronic medical or dental conditions which require painful diagnostic or therapeutic procedures.

Acknowledgement: The authors wish to express their profound gratitude for authorities, physicians and other personnel of Mahak and Mofid hospitals, as well as the young cancer patients and their parents who contributed to this study.

References:

1. Conte PM, Walco GA. Pain and procedure management. In: Brown RT (ed). Comprehensive handbook of childhood cancer and sickle cell disease: a biopsychosocial approach. New York: Oxford Univ Press; 2006: 120-32.
2. Zekry HA, Reddy SK. Opioid and nonopioid therapy in cancer pain: the traditional and the new. Curr Rev Pain 1999; 3(3): 237-47.
3. Zaza C, Sellick SM, Willan A, et al. Health care professionals' familiarity with non-pharmacological strategies for managing cancer pain. Psycho Oncol 1999; 8(2): 99-111.
4. Mercadante S. Cancer pain management in children. Palliat Med 2004; 18(7): 654-62.
5. Cline RJ, Harper FW, Penner LA, et al. Parent communication and child pain and distress during painful pediatric cancer treatments. J Pediatr Oncol Nurs 2007; 24(1): 8-19.
6. Blount RL, Zempsky WT, Jaaniste T, et al. Management of pediatric pain and distress due to medical procedures. In: Roberts MC, Steele RG. Handbook of pediatric psychology. 4th ed. New York: Guilford Press; 2009: 171-8.
7. Schechter NL. The development of pain perception and principle of pain control. In: Martin A, Volkmar FR (eds). Lewiss's child and adolescent psychiatry: a comprehensive textbook. 3rd ed. Philadelphia: Lippincott Williams Wilkins; 2002: 775-6.
8. Blount RL, McCormick ML, MacLaren JE, et al. Preparing children for invasive procedures and surgery. In: Walco GA, Goldschneider KR (eds). Pain in children: a practical guide for primary care. Totowa: Humana Press; 2008; 93-9.
9. Patterson, Ware LL. Coping skills for children undergoing painful medical procedures. Issues Compr Pediatr Nurs1988; 11(2-3): 113-43.
10. Caraceni A. Evaluation and assessment of cancer pain and cancer pain treatment. Acta Anaesthesiol Scand 2001; 45(9): 1067-75.
11. Lang SS, Patt RB. You don't have to suffer: A complete guide to relieving cancer pain for patients and their families. New York: Oxford Univ Press; 1994: 5-43.
12. McMahon SB, Koltzenburg M. Wall and Melzack's textbook of pain. 5th ed. UK: Elsevier; 2006: 127- 32.
13. McGrath PJ, Unruh AM. Measurement and assessment of pediatric pain. In: McMahon SB, Koltzenburg M (eds). Wall and Melzack's textbook of pain. 5th ed. UK: Elsevier; 2006: 169-76.
14. Turk DC, Melzack R. The measurement of pain and the assessment of people experiencing pain. In: Turk DC, Melzack R (eds). Handbook of pain assessment. 2nd ed. New York: Guilford Press; 2001; 3-10.
15. Schmidt RF, Willis WD. Encyclopedia of pain. New York: Springer; 2007: 31-50.
16. Tousignant-Laflamme Y, Rainville P, Marchand S. Establishing a link between heart rate and pain in healthy subjects: a gender effect. J Pain 2005; 6(6): 341-7.
17. Möltner A, Hölzl R, Strian F. Heart rate changes as an autonomic component of the pain response. Pain 1990; 43(1): 81-9.
18. Walco GA, Cassidy RC, Schechter NL. Pain, hurt, and harm: the ethics of pain control in infants and children. New Engl J Med 1994; 331(8): 541-4.
19. Ivani G, Mossetti V, Italiano S. Pediatric acute pain management In: Sinatra R, de Leon-Casasola OA, Ginsberg B, et al (eds). Acute pain management. New York: Cambridge Univ Press; 2009; 487-91.
20. Lichtman MA, Beutler E, Seligsohn U, et al. Williams hematology 7th ed. New York: McGraw-Hill; 2007: 670-75.
21. Powers SW, Blount RL, Bachanas PJ, et al. Helping preschool leukemia patients and their parents cope during injections. J Pediatr Psychol 1993; 18(6): 681-95.
22. McGrath PA, Brown SC. Pain in children. In: Argoff CE McCleane G (eds). Pain management secrets: questions you will be asked. Philadelphia: Mosby; 2009: 221-8.
23. Schechter NL. Treatment of acute and chronic pain in the out-patient setting. In: Finley GA, McGrath PJ, Chambers CT. Bringing pain relief to children: Treatment approaches. Totowa: Humana Press; 2006: 36.
24. Beyer JE, Villarruel AM, Denyes MJ. The Oucher: user's manual and technical report. Accessed November 1, 2009. Available from: http://www.oucher.org/downloads/2009_Users_Manual.pdf
25. Fuerst RS. Use of pulse oximetry. In: King C, Henretig FM. Textbook of pediatric emergency procedures. 2nd ed. Philadelphia: Lippincott Williams Wilkins; 2008: 750-4.
26. Zempsky WT, Schechter NL. Topical anesthetics and office-based procedures. In: Walco GA, Goldschneider KR. Pain in children: A practical guide for primary care. Totowa: Humana Press; 2008: 66.
27. Cohen LL, Bernard RS, Greco LA, et al. A child-focused intervention for coping with procedural pain: are parent and nurse coaches necessary? J Pediatr Psychol 2002; 27(8): 749-57.

28. Richards T, Johnson J, Sparks A, et al. The effect of music therapy on patients' perception and manifestation of pain, anxiety, and patient satisfaction. Med Surg Nurs 2007; 16(1): 7-14.
29. Prabhakar AR, Marwah N, Raju OS. A comparison between audio and audio-visual distraction techniques in managing anxious pediatric dental patients. J Indian Soc Pedod Prev Dent 2007; 25(4): 177-82.
30. De More M, Cohen LL. Distraction for pediatric immunization pain: a critical review. J Clin Psychol Med Set 2005; 12(4): 281-91.
31. Slifer KJ, Tucker CL, Dahlquist LM. Helping children and caregivers cope with repeated invasive procedures: how are we doing? J Clin Psychol Med Set 2002; 9(2): 131-52.
32. Bragado C, Fernández Marcos A, Fernández Marcos A. Psychological treatment of evoked pain and Anxiety by invasive medical procedures in Paediatric oncology. Psychol Spain 1997; 1(1): 17-36.
33. Cong X. Kangaroo care for analgesia in preterm infants undergoing heel stick pain [PhD dissertation]. Ohio: Frances Payne Bolton School of Nursing: Case Western Reserve University; 2006: 75.
34. Leo RJ. Clinical manual of pain management in psychiatry. Arlington: Am Psychiatr Publ; 2007: 18.
35. Ghori MK, Zhang YF, Sinatra RS. Pathophysiology of acute pain. In: Sinatra RS, deLeon-Casasola OA, Ginsberg B, et al. Acute pain management. New York: Cambridge Univ Press; 2009: 24-31.