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Effects of physiotherapy associated to virtual games in pain perception and heart rate variability in cases of low back pain

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ABSTRACT

Introduction: The virtual games when appropriately used can stimulate brain activity and excite the creative energy. Therefore, it is important to assess the implications of their use in pain perception in individuals with low back pain (LBP), a disease that affects about 80% of the world's population. **Objective:** was to evaluate the effects of virtual games combined with a physiotherapy program on the pain perception and Heart Rate Variability (HRV) in people with LBP. **Method:** the participants were 21 adults with clinical diagnosis of LBP, aged 24-61 years, of both sexes, divided into two groups. Five weekly meetings were provided. Group 1 participated in a physical therapy program and group 2 participated in the same physical therapy program plus joint sessions with virtual games. The instruments used were a heart rate monitor; a tablet for games; a shortwave equipment; visual analogue scale (VAS); and McGill's Pain Questionnaire. The measurements were performed before and after the program. **Results:** Reduction in pain was observed in both groups, being higher in group 2, the one that used the games. **Conclusion:** There was a decrease in parasympathetic activity in group 2, which indicates that the distraction factor promoted by the games influenced the pain perception.

Keywords: games, heart rate variability, pain, low back pain.

INTRODUTION

Low back pain is a musculoskeletal syndrome that affects much of the population at some point in life and, therefore, it is considered a serious public health problem.[1] It is a common cause of dysfunction and disability, causing a major social and economic impact on work productivity. In Brazil, diseases of the spinal column constitute the first cause of sick leave and the third cause of disability retirement. [2,3] Several factors may be associated with the presence of low back pain, such as age, gender, alcoholism, smoking, body mass index (BMI), education, social class, physical inactivity and some work activities.[4]

Due to the fact that low back pain has a multifactorial character, its treatment should be performed in a multidisciplinary way and physiotherapy is always a part of this process. There are several tools used for therapy in the treatment of low back pain (also known as lumbago) and there is a wide range of available treatment options for each dysfunction, acting in the relief of pain and in the functional recovery.[5,6] Among the possible treatments, the ones mostly recommended are postural exercises, global postural education (GPR), manual therapies, electro-thermotherapy and acupuncture.[7-9]

For the physiotherapeutic treatment of low back pain, electrotherapy and postural exercises for the lumbar spine were used in this research. Electrotherapy includes shortwave therapy, characterized by deep heat emission, indicated in the subacute and chronic phases as an adjunct to the inflammation and pain control. This treatment promotes the emission of electromagnetic radiation that induces heat to the deeper tissues.[10] Additionally, presents as therapeutic analgesic, anti-inflammatory and causes effects of hyperemia in the applied area.[11] Therefore, the use of heat in deep tissue levels causes muscle relaxation, reduces joint stiffness and improves local circulation.[12]

The vast majority of physiotherapeutic procedures also uses the supervised postural exercises that are effective in reducing pain and in improving functional performance of patients with chronic low back pain.[13,14] There are practices that use exercises performed in groups and others that use

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individual approaches. Both have good results in relieving pain and improving posture.[15,9,17]

In the face of the syndromic importance of low back pain, the need arises for research to seek innovative forms of assessment and treatment. Thus, new technologies have been tested as well as virtual games. Recent studies indicate that virtual games can be used as adjuvants in the treatment of various types of diseases.[18] Currently, virtual games represent a multibillion-dollar industry in the United States and although they have been associated with some negative issues when used in excess, they can also be useful for therapeutic purposes.[19] Their use has been common in psychotherapy, physiotherapy, physical activity, health education, in self-management of chronic diseases and to the pain distraction.[18]

Pain processes can be positively influenced by the use of virtual games[19] and, in some cases, they may be used in combination with physiotherapy.[20] Games tend to stimulate brain activity and creativity, which can be defined as a process in which there are many interactions between personality traits, cognitive abilities and environmental elements that help the individual to achieve creative discoveries.[21] This active process in the search for novel ideas to solve problems can be named “creative energy”.

Creativity can bring solutions to complex tasks related to unfavorable situations such as disease and pain.[22] In relation to health and disease, specifically in the case of pain, a condition in which creative energy is present can lead to what Csikszentmihalyi[23] denominated “flow”. This condition occurs when the brain is stimulated to the limit in a voluntary effort to accomplish something difficult, with high interest to individual. The resulting psychological state of this process is generally seen as positive mood, lack of time pressure or even the loss of perception that time is passing, high levels of attention and focus on the task.[23] In the same way, the perception of pain can be modified through the flow.

According to Villemure and Bushnell,[24] the state of attention is one of the most important psychological variables that could change the perception of pain. When attention is focused on a particular task that uses creative energy, this causes distraction to other sensations, and, according to Valet et al.[25] this distraction is associated with the activation of multiple areas of the brain, including the frontal cortex and other structures, and acts as a modulating factor of pain perception.

Functional magnetic resonance imaging (MRI) shows large declines in subjective pain measures during game activities and a decrease in brain activity related to pain. Clinical and laboratory evidence indicate that the distraction of pain through games is a new and promising non-pharmacological control technique.[19]

On research of Edwards, Beale and Edwards,[26] which compares the real game of chess and the virtual one, an increase in heart rate and stress was observed for both types of game, although the real chess presented significantly higher levels of stress than the virtual model. In another experiment with 19 participants where the HRV was observed during the immersion into virtual reality for 60 minutes, an increase in sympathetic activity and consequent decrease in parasympathetic activity could be observed during the procedures.[27]

HRV is recognized as a noninvasive tool for cardiac autonomic modulation.[28] HRV is seen as one of the most promising quantitative markers of autonomic balance. Changes in its patterns are able to provide reliable indicators of health impairments at various levels, and show clearly the role of the sympathetic and parasympathetic nervous system.[28-30]

There are several studies showing the relationship between changes in cardiac autonomic modulation and the presence of pain,[31,32] including back pain.[33] Thus, the autonomic nervous system may be largely influenced by painful stimulation and some physiological reactions, such as increased or decreased heart rate and variability, have been used to better understand the pain and its variables.[34]

This study aimed to relate the pain and its eventual decline with the treatment applied, on the cardiac autonomic responses, using the analysis of Heart Rate Variability (HRV). Therefore, the purpose of this research was to evaluate the effects of the use of virtual games combined with a physiotherapy program on pain perception and sympathovagal modulation of patients with low back pain.

METHOD

This research was approved by ethics committee with the number of protocol 640989, and followed the norms that regulate research on human beings, contained in Resolution 196/96 of *Conselho Nacional de Saúde*. The subjects were properly informed about the research and signed a free consent term with all explanations.

Participants

The sample consisted of 21 adults of both sexes, three men and 17 women, aged between 24 and 61 years, with clinical diagnosis of low back pain. Was used the systematic random and the participants were selected from the medical records following the order of registration, where the research was carried out. After the selection, the sample was randomized for the procedure and divided into two groups - Group 1 with eleven participants and Group 2 with ten participants, respectively.

Instruments

1. Polar ® ProTrainer 5 - RS800CX heart rate monitor, which is a validated instrument for the analysis of HRV as an investigative tool of cardiac autonomic function.[35]

2. Visual Analogue Scale (VAS), which evaluates the perception of pain intensity and consists of a straight line 10 centimeters long, without numbers, whose left end indicates "no pain" and whose right end indicates "worst pain possible" and the patient is instructed to self-assess, marking the point indicating the intensity of their pain.[36,37]
3. McGill's Pain Questionnaire, which is an inventory with 78 descriptors to characterize and distinguish the affective, the sensitive and the pain evaluative components, presenting important indexes for assessing pain, especially when applied for qualitative and quantitative information from verbal descriptions (MARTINS et al, 2012).[38]
4. Samsung tablet Galaxy Note 10.1, 2014 edition.
5. Tablet games: The Sims; Candy Crush Saga; Pet Rescue Saga; Mental Games; Bubble Poke; Farm Heroes Saga.
6. Automatic Thermopulse (Solid State), which is a diathermy equipment that generates short-wave radiofrequency energy (high frequency 27.12 MHz).

Procedure

The procedures were organized to individual meet each participant in seven meetings, the first and the last for the tests and interviews. From the second to the sixth meeting, that is, for five sessions, physiotherapy procedures were applied in Group 1. In the group 2, the physiotherapy was associated with tablet games. Each participant chose the game to be used, depending on your preference and affinity. These meetings were held in an appropriate room, silent and with controlled temperature of 22 to 24 degrees centigrade.

The instruments Polar ® ProTrainer 5 - RS800CX heart rate monitor, Visual Analogue Scale (VAS) and McGill's Pain Questionnaire were used in pre-test and post-test before and after the treatment.

The physiotherapy program for Group 1 included the application of shortwaves to the lumbar region during 20 minutes and therapeutic exercises which lasted approximately 15 minutes. Such exercises have the purpose of providing gain of lumbar flexibility and were arranged in three categories in which the patient performed three replicates lasting 30 seconds each. We used an individual approach with movements that aimed to gain flexibility of the lumbar spine through active exercises in three modes. The purpose was to reduce the pain, stabilize the torso and the pelvis, actively develop the flexors muscles and passively stretch the extensors muscles of the lumbar spine. The total procedure time for Group 1 was approximately 50 minutes for each participant.

In Group 2, the physiotherapy program was the same as used in Group 1. After that, the participants were told to sit in ergonomic chairs and initiate the games on tablet devices. The game activity lasted 20 minutes. Therefore, the total time of the procedure for Group 2 was approximately 70 minutes for each participant.

The analysis of HRV is expressed in milliseconds and measured every normal RR interval (which is the interval between two R waves and corresponds to the frequency of ventricular depolarization) during a certain time.[28,39] The rMSSD is the square root of the mean of successive heartbeat interval differences in a time period, also expressed in milliseconds.[40] The pNN50 measure represents the percentage of adjacent RR intervals with differences above 50ms between them. Therefore, the greater the temporal variability of the intervals between consecutive heart beats (RR), the greater the parasympathetic.[29, 41]

For the analysis of the data obtained from the variables studied, descriptive statistics were used and, according to the non-normal distribution of the sample, the Wilcoxon test was applied to compare the measurements of HRV and pain obtained at the beginning and the end of the program.

RESULTS

The average age of the sample was 46.81 years (46.36 for Group 1 and 47.30 for Group 2). The Table 1 shows a summary of mean results of the values obtained at the pre-test and post-test for the McGill Pain Questionnaire (EMD), Visual Analogue Scale (VAS), and RMSSD and pNN50 variables corresponding to the Variability of Frequency Cardiac (VFC).

Although Group 1, which was submitted only to the physiotherapy treatment, showed an increase in parasympathetic activity, these results were not significant. In contrast, Group 2, which made use of virtual games and physiotherapy showed a significant reduction in RMSSD and pNN50, what indicate a decrease in cardiac parasympathetic activity. Figure 1 shows the number of RR interval for the analysis of heart rate variability of a participant, measured for 5 minutes the way it was used in this research.

According to the McGill Pain Questionnaire, regarding the evaluation of pain perception, a predominance of the sensorial aspects was observed in both groups, followed by the affective aspects. There was a decrease of scores over time in both groups, which was significant ($p < .01$ **) for Group 1, as shown in Figure 2.

The results of the Visual Analogue Scale (VAS) indicated a significant decrease ($p < .01$ **) in pain perception scores for both groups, as shown in Figure 3.

Figure 4 shows the results of rMSSD, for which an increase was observed in Group 1 and a significant decrease ($p < .01$ **) in Group 2.

The pNN50 results are illustrated in Figure 5 and show differences between the groups and a significant decrease ($p < .05^*$) for Group 2.

DISCUSSION

Both groups that participated in the physiotherapy program showed significant reduction in pain levels, which was confirmed by the analysis of the VAS and McGill indexes. Although Group 2 showed greater reduction in pain levels after treatment, which is attributed to an effect of the game, the same group showed decreased cardiac parasympathetic action. This suggests that the excitement of the game caused both effects, namely, a reduction in pain levels and an increased cardiac parasympathetic tone.

Shortwave equipment is frequently used in physiotherapy procedures to control low back pain, therapeutic modality which uses heat delivered by radio frequency bands. This procedure can be associated with other treatment techniques such as, for example, postural exercises.[9,11,42]

In a experimental randomized study involving 97 patients of both sexes between 20 and 80 years of age, who complained about chronic back pain, shortwave was used in physiotherapy, a significant improvement was observed after the end of the third week. However, in most of these patients the improvement can only be observed after the sixth week of treatment, with a significant reduction in pain.[42] Therefore, it is recommended the use of shortwave for the treatment of pain in musculoskeletal disorders and low back pain, since many cases are known with promising results.[11]

Table 1. The mean results and standard deviations of the values at the pre-test and post-test for the McGill Pain Questionnaire (EMD). Visual Analogue Scale (EVA). and pNN50 and RMSSD variables.

GROUP 1	N	Pre-test		Post-test	
Variables		Mean	SD	Mean	SD
MPQ	11	48.18	11.5	33.09	10.98
VAS	11	7.18	0.6	3.32	1.63
RMSSD	11	26.31	25.11	29.4	19.76
pNN50	11	8.63	16.51	8.84	9.84
GROUP 2	**N**	**Pre-test**		**Post-test**	
Variables		**Mean**	**SD**	**Mean**	**SD**
MPQ	10	46.6	13.31	32.2	18.09
VAS	10	6.7	1.06	1.4	1.17
RMSSD	10	41.28	24.01	27.59	25.65
pNN50	10	17.6	19.66	11.16	21.22

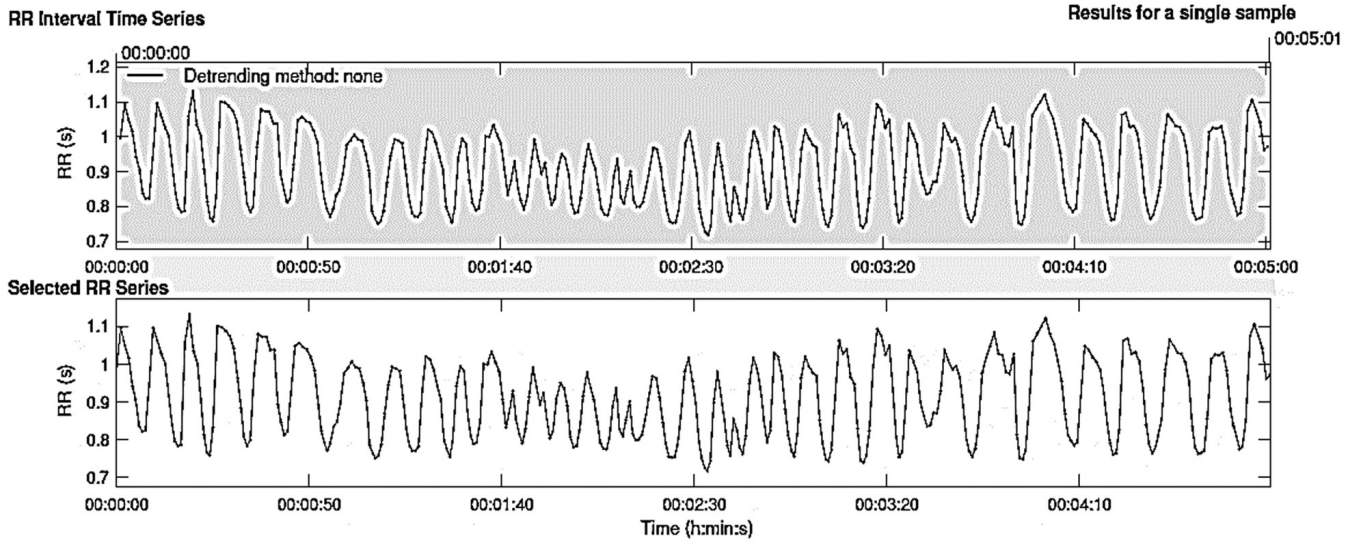

Figure 1. The RR interval time series for the analysis of heart rate variability of a participant, measured during 5 minutes.

Physical pain should be considered as an individual and subjective experience, since it has a multidimensional character. It is influenced by many variables, such as gender, race, affective and emotional issues, among others.[43] Martins et al.[38] agree that the tools to measure pain, such as VAS and the McGill questionnaire, have good discriminative power and help in the investigation of the various dimensions of symptoms, either qualitatively or quantitatively.

The data presented in this study indicated improvement in pain for both groups. There were significant differences in the results of McGill pain questionnaire for Group 1 and the results of VAS measured at the beginning and end of the program for both groups, but especially for group 2, the one that made use of games. According to Hoffman et al.[44] and Primack et al.[19] several studies indicate that virtual reality and video games

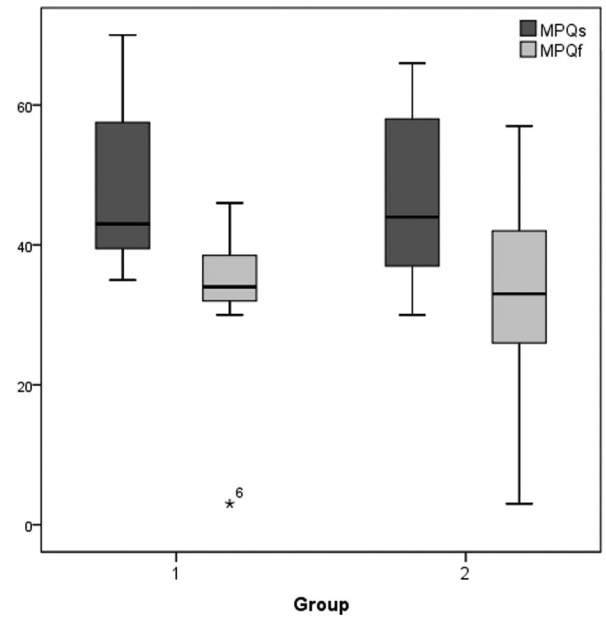

Figure 2. Box plot illustrating the results of the McGill Pain Questionnaire MPQ (*s*) in the pre-test and the MPQ (f) in the post-tests (f) for groups 1 and 2.

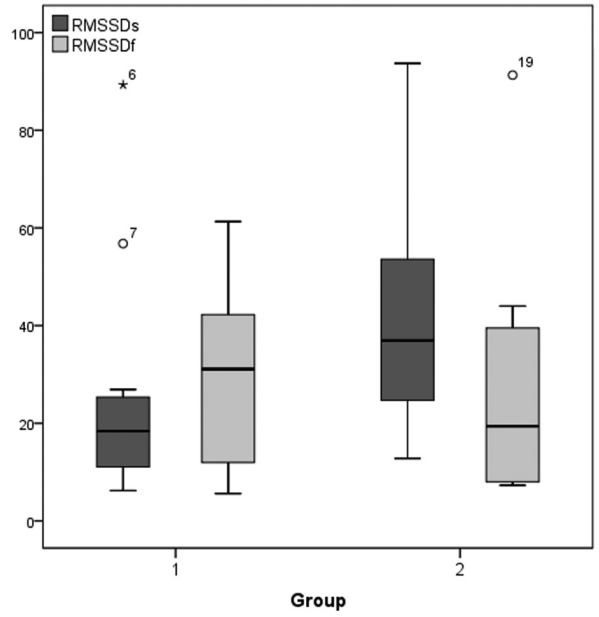

Figure 4. Results of RMSSD (s) s in the pre-test and the RMSSD (f) in the post-tests (f) for groups 1 and 2.

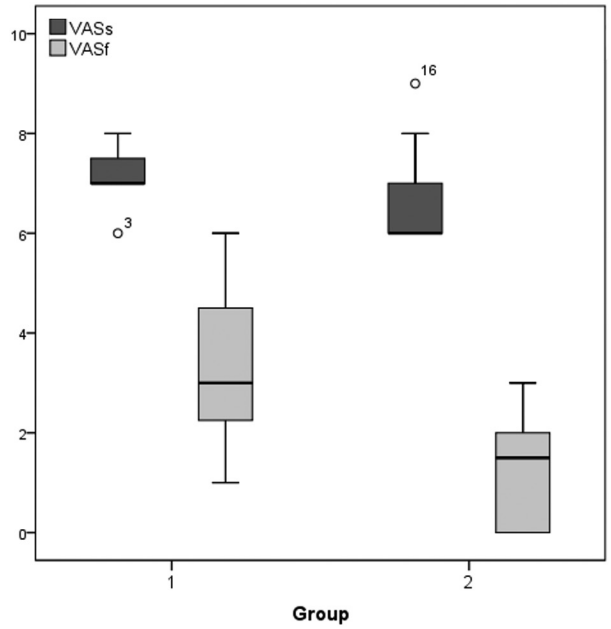

Figure 3. Graphic illustrating the results of the VAS (*s*) in the pre-test and the VAS (f) in the post-tests (f) for groups 1 and 2.

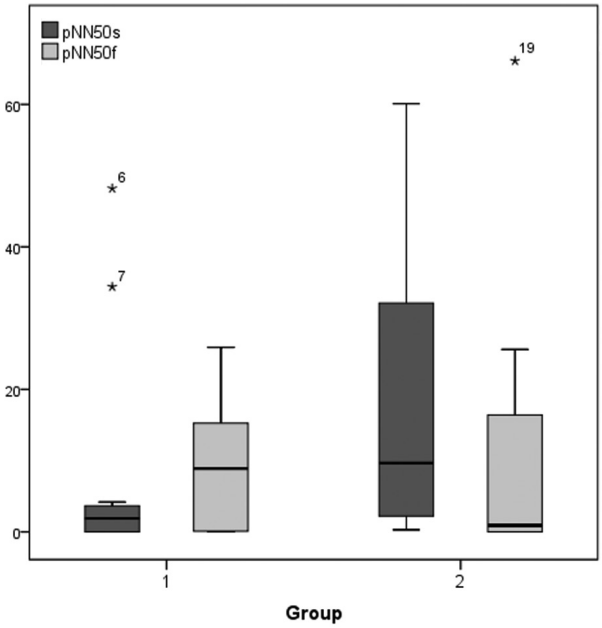

Figure 5. Results of pNN50 (s) s in the pre-test and the pNN50 (f) in the post-tests (f) for groups 1 and 2.

can help in the treatment of some diseases and contribute to the change in the perception of pain by reducing its measures.

The creative energy used during activities with games induce the state of flow. This condition causes high levels of attention, good mood, loss of perception of time and focus on the task.[23] Therefore, the attention given to the games also modulates the perception of pain by activating multiple brain regions, including the frontal cortex.[25]

HRV was utilized as a guiding parameter to the neurophysiological responses front to the proposed treatment and the use of games, the HRV was utilized. According to Ferreira et al.[31] HRV is used as a tool for evaluating physiotherapeutic interventions, although few studies have been published on the use of HRV as a resource for assessing this type of intervention, which demonstrates the lack of research in this field. In addition, the studies found by these authors are mainly related to the cardiorespiratory area of physiotherapy, suggesting the lack of implementation of this evaluation feature in others circumstances, as well as in orthopedics and musculoskeletal pain.

Regarding the HRV results, was observed a significant reduction in RMSSD and pNN50 measures for Group 2, which indicate the predominant role of vagal,[45] suggesting, therefore, a decrease in the participants' cardiac parasympathetic activity. Therefore, the reduction in parasympathetic activity is associated with the neurophysiological action induced by the creative energy employed during the games.

Based on these assumptions, the results of the HRV analysis in the present study suggest that the excitement caused by the game was responsible for a decreased cardiac parasympathetic tonus. This is opposed to the effect commonly observed in cardiac autonomic modulation, in which the reduction of pain is related to the increase of the cardiac parasympathetic component.

Probably, in this study, the pain reduction was not directly associated with the performance of the autonomic nervous system, but with the creative energy caused by the use of games. Several tools can be used for pain distraction as a modulation factor, among which virtual games occupy a prominent.[46]

According to Valet et al.[25] the distraction from pain is associated with a significant reduction in the VAS and other tools used for the classification of its intensity. The distraction, in this case, relates to the creative energy in the activation of multiple areas of the brain, including the frontal cortex, together with other structures acting as modulators of pain perception. It works through a process of attention. The attention state is, probably, the most common studied psychological variable that changes the perception of pain.[24]

CONCLUSION

All participants of the study showed reduced levels of pain perception but those who underwent the treatment associated with use of games, although showing a significant reduction of parasympathetic markers, showed greater reduction in the VAS and McGill indexes, which indicates that creative energy acted as a factor of distraction from pain.

The number of participants was a limiting factor in this search. Future studies with larger samples could provide information to extend our understanding of low back pain, its manifestations, management and modulation methods.

On conclusion, the appropriate use of games on tablet devices may favor the management of low back pain, stimulating creative energy, which promotes distraction from pain and reduces its perception indexes.

AUTHORS' CONTRIBUTIONS

Sergio Fernando Zavarize (author 1) contributed specifically in the conception and research design, data collection, analysis and interpretation of data, statistical analysis and writing of the manuscript. Mário Augusto Paschoal (author 2) contributed to the conception and design of the research, analysis and interpretation of data and writing of the manuscript. Solange Muglia Wechsler (author 3) contributed to the conception and design of the research, analysis and interpretation of data and writing of the manuscript.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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REFERENCES

1. Medeiros JD, Souza Pinto AP. Impacto social e econômico na qualidade de vida dos indivíduos com lombalgia: revisão sistemática. Caderno de Graduação-Ciências Biológicas e da Saúde-FITS. 2014;2(1):73-8.
2. Almeida MCV, et al. Prevalência de doenças musculoesqueléticas entre trabalhadores portuários avulsos. Rev. Latino-Am Enfermagem. 2012;20(2):243-50.
3. Noll M, et al. Prevalence of back pain and associated factors in elementary school students in the town of Teutônia, Rio Grande do Sul. Rev. Brasileira de Saúde Materno Infantil. 2012;12(4):395-402.
4. Barbosa MH, et al. Lombalgia: fatores de melhora e piora entre os clientes atendidos no ambulatório de ortopedia. Saúde Coletiva. 2011;8(47):18-23.
5. Garcia NA, et al. Efeitos de duas intervenções fisioterapêuticas em pacientes com dor lombar crônica não específica: viabilidade de um estudo controlado aleatorizado. Rev. Bras Fisioter. 2011;15(5):420-27.
6. Santos Araujo AG, Oliveira L, Liberatori M F. Protocolo Fisioterapêutico no Tratamento da Lombalgia. Cinergis. 2013;13(4):56-63.
7. Zavarize SF, Wechsler SM. Efeito de Tratamentos Fisioterapêuticos Convencionais Sobre Casos de Lombalgia. Intellectus – Rev. Acad. Facs. Unopec. 2011;15:116-31.
8. Godoy JRP, et al. Efeito da acupuntura na dor lombar: revisão de literatura. Doi: 105102/ucs. v12i1. 2593. Universitas: Ciências da Saúde. 2014;12(1):49-57.
9. Costa MC, et al. Perfil Epidemiológico e Clínico dos Pacientes com Queixa de Dor Lombar Atendidos em uma Clínica Escola de Fisioterapia. Movimenta. 2015;8(1):37-42.
10. Assunção MLAC, Ramos AAT, LIMA BA. Termoterapia profunda como tratamento fisioterapêutico na osteoartrite. Revista de Ciências Médicas. 2012;19(1-6):73-9.

11. Zavarize SF, et al. Diatermia por Ondas Curtas: análise da temperatura corporal superficial por termografia. Biológicas & Saúde. 2014; 12(4):35-47.
12. Biasoli MC, Izola LNT. Aspectos gerais da reabilitação física em pacientes com osteoartrose. Rev. Bras Med. 2003;60(3):133-6.
13. Costa LO, et al. Motor control exercise for chronic low back pain: a randomized placebo-controlled trial. Phys Ther. 2009;89(12):1275-86.
14. Van Middelkoop M, et al. Exercise therapy for chronic nonspecific low-back pain. Best practice & research Clinical rheumatology. 2010;24(2):193-204.
15. Garcia NA, et al. Control exercise for chronic low back pain: a randomized placebo-controlled trial. Phys Ther. 2009;89(12):1275-86.
16. Korelo RIG, et al. Effect of group program of kinesiotherapy with Back School for chronic low back pain. Fisioterapia em Movimento. 2013;26(2):389-94.
17. Lima PAL, Amorim DG. Jogos que Auxiliam no Tratamento se Enfermidades: Serious Games. Revista Opara. 2014;4(1):57-70.
18. Hoffman HG, et al. Using fMRI to study the neural correlates of virtual reality analgesia. CNS spectrums. 2006;11(1):45-51.
19 Primack BA, et al. Role of video games in improving health-related outcomes: a systematic review. American journal of preventive medicine. 2012;42(6):630-8.
20. Morris LD, Louw QA, Grimmer-Somers K. The effectiveness of virtual reality on reducing pain and anxiety in burn injury patients: a systematic review. The Clinical journal of pain. 2009;25(9):815-26.
21. Wechsler SM. Criatividade: descobrindo e encorajando. Campinas: Impressão Digital do Brasil; 2008.
22. Zavarize SF, Wechsler SM. Perfil criativo e qualidade de vida: implicações em adultos e idosos com dor lombar crônica. Rev. Bras Geriatr Gerontol. 2012;15(3):403-14.
23. Csikszentmihalyi M. Flow. In: Flow and the Foundations of Positive Psychology. Springer Netherlands;2014:227-38. Doi: 10.1007/978-94-017-9088-8_15.
24. Villemure C, Bushnell MC. Cognitive modulation of pain: How do attention and emotion influence pain processing? Pain. 2002;95:195–9.
25. Valet M, et al. Distraction modulates connectivity of the cingulo-frontal cortex and the midbrain during pain—an fMRI analysis. Pain. 2004;109(3):399-408.
26. Edwards DJ, Beale JT, Edwards SD. Influence of actual and virtual chess on neurophysiology and cognition: sport psychology. African Journal for Physical Health Education, Recreation and Dance. 2012;18(4-1):780-6.
27. Malińska M, et al. Heart rate variability (HRV) during virtual reality immersion. International Journal of Occupational Safety and Ergonomics. 2015;21(1):47-54.
28. Vanderlei LCM, et al. Noções básicas de variabilidade da frequência cardíaca e sua aplicabilidade clínica. Rev. Bras Cir Cardiovasc. 2009;24(2):205-17.
29. Paschoal MA, Polessi EA, Simioni FC. Evaluation of heart rate variability in trained and sedentary climacteric women. Arquivos brasileiros de cardiologia. 2008;90(2):80-6.
30. Paschoal MA. Fisioterapia cardiovascular – avaliação e conduta na reabilitação cardíaca. 1a. ed., Manole; 2010.
31. Ferreira LL, et al. Variabilidade da frequência cardíaca como recurso em fisioterapia: análise de periódicos nacionais. Fisioter mov. 2013;26(1):25-36.
32. Zamunér AR, et al. Relationship between sympathetic activity and pain intensity in fibromyalgia. Clinical and experimental rheumatology. 2014;33(1):53-7.
33. Ventura PL, Paula Junior AR, Oliveira MA. Análise da variabilidade da frequência cardíaca em jovens saudáveis na postura sentada através do método Isostretching. Rev. Terapia Manual. 2010;8(39):401-7.
34. Colloca L, Benedetti F, Pollo A. Repeatability of autonomic responses to pain anticipation and pain stimulation. European Journal of Pain. 2006;10(7):659-665. Doi: 10.1016/j.ejpain.2005.10.009.
35. Quintana DS, Heathers JA, Kemp AH. On the validity of using the Polar RS800 heart rate monitor for heart rate variability research. Eur J Appl Physiol. 2012;112(12):4179-80.
36. Sousa FF, SILVA, JA. A métrica da dor (dormetria): problemas teóricos e metodológicos. Rev. Dor. 2005;6(1):469-513.
37. Bryce TN, et al. Pain after spinal cord injury: an evidence-based review for clinical practice and research: report of the National Institute on Disability and Rehabilitation Research Spinal Cord Injury Measures meeting. The journal of spinal cord medicine. 2007;30(5):421-40.
38. Martins MRI, et al. Uso de questionários para avaliar a multidimensionalidade e a qualidade de vida do fibromiálgico. Rev Bras Reumatol. 2012;52(1):21-6.
39. Paschoal MA, Trevizan PF, Scodeler NF. Variabilidade da frequência cardíaca, lípides e capacidade física de crianças obesas e não-obesas. Arq Bras Cardiol. 2009; 93(3):239-46.
40. Fiogbé E, et al. Função autonômica cardíaca e nível de atividade física de pacientes com doença arterial coronariana. Revista Brasileira de Atividade Física & Saúde. 2014;19(5):579-80.
41. Sá JCF, et al. Heart rate variability as a method of assessing the autonomic nervous system in polycystic ovary syndrome. Revista Brasileira de Ginecologia e Obstetrícia. 2013;35(9):421-26.
42. Rached RDVA, et al. Chronic nonspecific low back pain: rehabilitation. Rev. Assoc Med Bras.2013;59(6):536-53.
43. Martinez JE, Grassi DC, Marques LG. Análise da aplicabilidade de três instrumentos de avaliação de dor em distintas unidades de atendimento: ambulatório, enfermaria e urgência. Rev. Bras Reumatol. 2011;51(4):299-308.
44. Hoffman HG, et al. Virtual reality as an adjunctive non-pharmacologic analgesic for acute burn pain during medical procedures. Annals of Behavioral Medicine. 2011;41(2):183-91.
45. Paschoal MA, Petrelluzzi KFS, Gonçalves NVO. Estudo da variabilidade da frequência cardíaca em pacientes com doença pulmonar obstrutiva crônica. Rev. de Ciências Médicas. 2002;11(1):27-37.
46. Jameson E, Trevena J, Swain N. Electronic gaming as pain distraction. Pain Research & Management: The Journal of the Canadian Pain Society. 2011;16(1):27-32.