Original paper

Cryochamber safety – effects of a single session on ECG-derived parameters

Wpływ pojedynczej sesji w kriokomorze na parametry z EKG

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Słowa kluczowe: bezpieczeństwo kriokomory, krioterapia, elektrokardiogram, wektokardiografia.

Abstract

Introduction: Cryotherapy is a therapeutic method used to reduce pain associated with, among others, injuries and inflammation by both young athletes and the elderly.
Aim of the research: To investigate the effect of a single cryochamber session on basic ECG-derived parameters in adult non-athletes.
Material and methods: A hundred and eight participants without significant cardiac disorders were included in the study. A single session in the cryochamber lasted for 3 min, and the temperature within the appropriate chamber ranged from –150°C to –160°C. When in the cryochamber, each participant wore a tank top, shorts, a surgical mask, a cap, woollen gloves, socks, and wooden clogs. ECG parameters, as well as systolic and diastolic blood pressure were recorded both before and immediately after the cryochamber session. Moreover, vectorcardiographic parameters were generated according to the inverse Dower matrix.
Results: The study was performed on 72 females and 36 males with an average age of 50 years; no significant differences were demonstrated between these groups. We observed a statistically significant decrease in the heart rate and QTc interval after the cryochamber session, as well as a minor increase of QRS interval following the cryochamber session. No changes in the spatial QRS-T angle were observed.
Conclusions: Based on the collected results, whole-body cryotherapy in a cryochamber seems to be a harmless additional treatment for non-athlete adults without known contraindications for such therapy. Long-term prospective studies are necessary to confirm these results and to prove the safety of cryochambers on a larger group of subjects.

Streszczenie

Wprowadzenie: Krioterapia jest metodą leczniczą stosowaną do zmniejszenia dolegliwości bólowych związanych m.in. z urazami i stanami zapalnymi zarówno przez młodych sportowców, jak i osoby starsze.
Cel pracy: Ocena bezpieczeństwa pojedynczej sesji w kriokomorze na parametry sercowo-naczyniowe u dorosłych uczestników badania niebędących sportowcami.
Materiał i metody: W badaniu wzięło udział 108 pacjentów bez istotnych zaburzeń kardiologicznych. Pojedyncza sesja w kriokomorze trwała 3 min, a temperatura w głównej komorze chłodzącej wynosiła między –150°C a –160°C. Wszyscy uczestnicy badania w trakcie sesji w kriokomorze byli ubrani w koszulki, krótkie spodenki, chirurgiczne maski, czapki, wełniane rękawiczki, skarpetki oraz drewniane klapki. Badanie EKG oraz pomiar skurczowego i rozkurczowego ciśnienia wykonywano zarówno przed pobytem, jak i bezpośrednio po pobycie w kriokomorze. Dodatkowo na podstawie wyników uzyskanych z EKG wyliczono parametry wektokardiograficzne.
Wyniki: Łącznie w badaniu wzięło udział 72 kobiety i 36 mężczyzn ze średnią wieku wynoszącą 50 lat. Wyniki uzyskane z grupy kobiet i mężczyzn nie różniły się znacząco. Bezpośrednio po pobycie w kriokomorze zaobserwowano istotny statystycznie spadek częstości rytmu serca, skrócenie odstępu QTc oraz wydłużenie zespołu QRS. Nie stwierdzono istotnych zmian w przestrzennym kącie QRS-T przed pobytem i po pobycie w kriokomorze.
Wnioski: Na podstawie przeprowadzonego badania wydaje się, że krioterapia całego ciała w kriokomorze jest bezpieczną dodatkową opcją terapeutyczną dla dorosłych pacjentów bez obecnych istotnych przeciwwskazań do takiej terapii. Dalsze badania dotyczące bezpieczeństwa pobytu w kriokomorze są jednak konieczne do potwierdzenia tych wyników w większej liczbie badanych.

Introduction

Cold therapy can be applied in order to reduce pain and swelling following an injury or to treat an inflammatory response due to physical exercise. Thus, it can be advised as an early treatment of common orthopaedic conditions such as sprains and fractures [1, 2]. Nevertheless, recent studies have demonstrated that cryotherapy can be a beneficial supplementary treatment for cutaneous lesions [3] and can also be part of a rehabilitation process of patients with rheumatoid diseases such as arthritis and fibromyalgia [4–6].

Although there are several cryotherapy subtypes, the most commonly used is whole-body cryotherapy (WBC). WBC is an exposure to very cold air that is maintained at the temperature of –110°C to –160°C, which takes place in a specially designed cryochamber [7]. One session usually lasts up to 3 min. When performed under qualified supervision, cryochamber therapy is considered to be a safe additional treatment for healthy patients without any cardiac disorders. However, there are some contraindications for such therapy: Raynaud disease, cryoglobulinaemia, severe cold intolerance, unstable angina pectoris, heart failure, local blood flow disorders, claustrophobia, and psychiatric disorders precluding the patient's adjustment for instructions, among others [8].

Despite widespread use of the cryochamber in sports medicine, there have been few studies examining the cryochamber's effect on a basic electrocardiogram (ECG) in non-athletes.

Aim of the research

The aim of this study was to investigate the influence and safety of a single cryochamber session on changes in the basic ECG and cardiovascular parameters in adult non-athlete patients.

Material and methods

The Bioethical Commission at Jan Kochanowski University in Kielce, Poland approved this study with decision number 42/2019. Each participant provided written consent.

The study was performed on 108 adults without any significant cardiac disorders. All available patients from Kielce and Lublin were included in this study. To exclude any contraindications to cryochamber therapy, each patient was interviewed and examined by a physician prior to the start of the experiment. No exclusion criteria, besides the main contraindications to cryochamber therapy, were determined.

To adjust to the temperature of the facility, patients were instructed to arrive to the cryotherapy centre approximately 30 min before a single cryochamber session and, while in the chamber, wear only a tank top, shorts, a surgical mask, a cap, woollen gloves, socks, and wooden clogs.

The cryochamber session lasted for 3 min. Participants spent the first 30 s in an adaptive vestibule, where the temperature fluctuated around –60°C. Subsequently, they entered the appropriate chamber, where the temperature ranged from –150°C to –160°C.

The electrocardiographic test was conducted by the same physician both before and immediately after the single cryochamber session, while expecting physical exercises. The examination did not exceed 2 min. The basic ECG was assessed with a Cardiax device (IMED Co. Ltd., Budapest, Hungary) and brachial systolic and diastolic pressure were assessed with SphygmoCor® Xcel. The following parameters were recorded, measured, and compared before and after single cryochamber session: brachial systolic and diastolic pressure, heart rate, QRS complex, and QTc interval. Moreover, based on the 12-lead ECG, vectorcardiographic parameters were generated according to the inverse Dower matrix. The spatial QRS-T angle was measured and assessed using Cardiax PC-ECG software.

Results

The study population consisted of 72 females and 36 males, with an average age of 50 years. However, no significant differences were found between the groups. Basic clinical and ECG parameters for all participants are included in Table 1. To assess the statistical significance the Wilcoxon Signed-Rank test was conducted for each parameter before and after the cryochamber session. A statistically significant decrease in heart rate and QTc interval after the cryochamber session, as well as a minor increase of QRS interval after the cryochamber session, were observed.

Discussion

Our study generated 3 major findings: (1) a decrease in heart rate was observed after a single session in the cryochamber; (2) a decrease in QTc interval and increase in QRS interval were observed after a single session in the cryochamber; (3) no changes in QRS-T angle were observed after a single session in the cryochamber.

Cold therapy's benefits, widely reported primarily in sports medicine, limit the spread of muscle lesions following physical activity. The body's physiological response to being exposed to cold causes the constriction of arterioles and venules, and consequently results in a decrease in blood flow to the inflamed or injured tissues and sectional metabolic process. Thanks to these qualities, whole-body cryotherapy relieves the pain and inflammation associated with multiple conditions [1, 3, 6, 9–12].

Basing on our group of participants (heterogenic in sex and age), we conclude that solely minor alterations in cardiovascular parameters were demonstrated. No changes in systolic and diastolic pressure were report-

Table 1. Physiological and clinical characteristics of the examined participants (N = 108). The values are as follows: mean ± SD, minimum, maximum, and p-value (bold results < 0.0500 are statistically significant)

Parameter	Mean ± SD	Min.	Max.	*P*-value
Age [years]	50.83 ±11.29	31.0	78.0	–
Brachial systolic pressure 1 [mm Hg]	139.53 ±17.55	98.0	170.0	0.329
Brachial systolic pressure 2 [mm Hg]	141.06 ±18.23	106.0	181.0	
Brachial diastolic pressure 1 [mm Hg]	84.56 ±9.88	59.0	107.0	0.175
Brachial diastolic pressure 2 [mm Hg]	83.89 ±8.75	69.0	110.0	
Heart rate 1 [bpm]	74.00 ±11.42	58.0	105.0	
Heart rate 2 [bpm]	69.31 ±9.64	54.0	88.0	**< 0.001**
QRS 1 [ms]	97.44 ±9.38	84.0	120.0	
QRS 2 [m]	99.11 ±10.14	84.0	128.0	**0.007**
QTc 1 [ms]	432.33 ±18.37	400.0	483.0	
QTc 2 [ms]	427.19 ±23.87	390.0	508.0	**< 0.001**
QRST D 1	23.83 ±12.60	4.3	61.2	
QRST D 2	23.75 ±13.28	1.8	60.8	0.949

1 – before single session in cryochamber, 2 – after single session in cryochamber, QRST D – QRS-T angle with inverse Dower matrix.

ed. We observed a minor yet significant decrease in heart rate immediately after the cryochamber session (before WBC: 74.00 ±11.42; after WBC: 69.31 ±9.64; $p < 0.001$), which is in concordance with previously conducted studies [13–16]. Activation of the sympathetic component of autonomic nervous system (ANS) and α-adrenergic fibres may partially explain the heart rate lowering due to peripheral vasoconstriction to prevent heat loss and blood redistribution to increase central blood flow through large vessels [14, 16–18]. An additional mechanism may be associated with suppressed pain sensations, which in normal conditions provokes an increase of the heart's response. Extreme cold stimulation in a cryochamber may reduce such sensations and result in a decrease in heart rate. The results of Durand *et al.* and Flouris *et al.* [19, 20] support this mechanism, although there is a group of authors who did not report such outcomes and contradicted this theory [17, 21]. Hausswirth *et al.* observed the correlation between decreasing of skin temperature followed by lowering of heart rate [13]. Notwithstanding, LeBlanc *et al.* noted that extreme cooling of the body's uncovered parts, especially the face, could cause increased activity of the parasympathetic component of the autonomic nervous system and consequently lead to heart rate reduction [22, 23]. It seems that the causes of decreased heart rate after a cryochamber session are multifactorial and can be associated with combined activation of both components of the ANS [15].

In the present study we observed an increase in QRS interval (before WBC: 97.44 ±9.38; after WBC: 99.11 ±10.14; $p < 0.0069$) and a decrease in QTc interval (before WBC: 432.33 ±18.37; after WBC: 427.19 ±23.87; $p < 0.000001$) immediately after the cryochamber session. Even though the outcomes reached statistical significance, from a clinical point of view these changes are probably of little importance. It is mostly caused by the fact that for all participants, these parameters remained within the reference values. There were few studies that tested the cryochamber's therapy effect on the changes in the ECG. Coppi *et al.* reported no significant changes in the main ECG intervals (PR, QT, and Qtc). However, the study was based on 10 volunteer, middle-distance, non-professional, male runners [5]. Basing on findings from our research study, we cannot determine the potential mechanism responsible for the changes observed in the ECG, and thus further studies associated with the topic are required. Despite the observed minor impact on QRS and QTc intervals, a single session in a cryochamber does not significantly affect the ECG parameters, which may denote its safety in participants with significant disorders.

The spatial QRS-T angle, obtained from the basic 12-lead ECG, is the angle between the vectors of the QRS loops and the T-wave, which indirectly reflects ventricular depolarization and repolarization. An abnormally wide spatial QRS-T angle was defined as > 116° for females and > 130° in males [24, 25]. We did not observe significant changes in the the QRS-T angle, which may confirm that a single session in a cryochamber does not significantly affect depolarization and repolarization.

Conclusions

Based on our findings, we conclude that whole-body cryotherapy in a cryochamber appears to be

a safe additional treatment for adult female and male patients without known contraindications for such therapy. Nevertheless, further studies should be conducted to confirm these encouraging results on a larger group of non-athlete subjects.

Conflict of interest

The authors declare no conflict of interest.

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