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Original Research

Effect of Novel Cryotherapy Method on Frequency Spectrum of Lower Limb Muscles during Running and Walking

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ABSTRACT

Cryotherapy is one of the important factors in changing muscular function. The purpose of the present study was to investigate the effect of using novel cryotherapy method on frequency spectrum of lower limb muscles during running and walking before and after muscular fatigue. This study was quasi-experimental. Ten male novice soccer players volunteered to participate in this study. A wireless electromyography system with 8 pairs of surface electrodes was used to record the electromyography activity before and after muscular fatigue in temperature of 8 and 11 º C during walking and running. During walking, frequency spectrum of rectus femoris muscle after fatigue at 11 ° C was greater than before fatigue by 16.43% (p=0.047). Frequency spectrum of semi-tendentious muscle after fatigue at 11 ° C was higher than before fatigue by 38.11% (p=0.044). In addition, frequency spectrum of rectus femoris muscle after fatigue at 8 ° C was higher than before fatigue during running by 28.56% (p=0.031). Cryotherapy increased the frequency spectrum at 11 ° C in the semi-tendentious and rectus femoris muscles during walking and increased the frequency spectrum at 8 ° C in the rectus femoris muscle during running. It seems that using cryotherapy after fatigue may improve muscle function during different activities.

Keywords: Automatic cooling device, Electromyography, Fatigue, Running

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Introduction

Walking and running used during every day activities, commonly (1-8). Fatigue is one of the important factors that affects on stability of lower extremity during walking and running (9). Previous studies have been shown that lower extremity injuries can exacerbate during fatigue (10-12). Fatigue reduces muscle strength and therefore disturb functional capacity (13). Acute injuries may be caused by intense activity (14). Cryotherapy commonly used for the treatment of acute injuries (15-17). The effects of cryotherapy are associated with a decrease in neuromuscular function due to cold application (18). There is conflicting evidence about how cryotherapy affects muscle activity. Therefore, further researches needed on the effects of cryotherapy on the parameters such as frequency content of muscle activity. Most previous studies have also focused on the effects of cryotherapy using ice packs and sprays (15-17). While the use of a novel technology with this aim that accurately adjust the temperature, intensity during cryotherapy can possibly have better effects on muscle function and athletic performance. The effectiveness of cryotherapy in the field of sports, especially immediately after intense physical activity, remains subject to conflicting questions and opinions, and this needs further study. Therefore, the purpose of the present study was to investigate the effect of using cryotherapy on frequency spectrum of lower limb muscles during running and walking before and after muscular fatigue.

Material and Methods

Participants

This study was quasi-experimental with pre-test and post-test design. Using G * Power software, it was found that to achieve statistical power of 0.8, effect size of 0.8, and significance level of 0.05 required at least 10 statistical samples. Therefore, 10 soccer players were selected to participate in the present study. The subjects were selected by available sampling.

Inclusion criteria included: having at least 3 years of club activity; not having pain in the past 3 months; not having surgical history (knee, spine, hip, and ankle) and age range between 20 to 25 years. Descriptive statistics of age, height, weight, and body mass index was 23.70 ± 4.29 year, 172.52 ± 6.72 cm, 72.82 ± 12.22 kg and 21.84 ± 3.82 kg/m^2, respectively.

Exclusion criteria was history of skeletal muscle dysfunction, history of arthritis, chronic arthritis infection or bone disease, low back pain, ligament injury, ligament remodeling, and muscle disorders.

Experiment procedure

An electromyography system (Biometrics Ltd, England) was used to record muscle activity. Electromyography activity of the muscles during running and waking before and after cryotherapy at 8 and 11 ° C. Muscle activities of gastrocnemius medialis (GM), vastus medialis (VM), vastus lateralis (VL), rectus femoris (RF), biceps femoris (BF), semitendinosus (Glut-M), gluteal medius and tibialis anterior (TA) were recorded by electromyography system. The position of the electrodes on each muscle was according to the SENIAM protocol (19). The electrodes were positioned on each muscle in the direction of the muscle fibers. Sampling rate of 1000 Hz, low-pass filters of 500 Hz, high-pass filter of 10 Hz as well as notch filter (60 Hz) were used to smooth electromyography data (20-22).

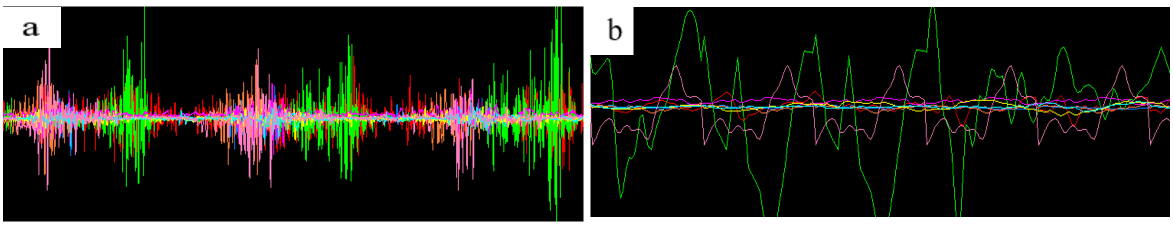

Figure 1. a) Raw signal, b) Signal cut during the running phase

Figure 2. Maximum isometric voluntary contraction for quadriceps muscles

Figure 3. Activity of selected lower limb muscles during running

Fatigue Protocol

The fatigue protocol in the present study was created by running on a treadmill. The Borg scale was used to detect fatigue onset. To produce fatigue in subjects, the fatigue protocol of running at a constant speed was used. The speed of the subjects on the treadmill was initially 6 km / h at the same time, the subjects were asked to report their severity of pain on a 15-point Borg scale (6 to 20). This was also controlled by heart rate. The running speed increased by 1 km / h every two minutes. When the person reported the thirteen, the subject then continued running at the same rate until the Borg score reached Seventeen or the heart rate reached 80% of maximal heart rate. At this point, the person was asked to run for two minutes more. Immediately after the fatigue protocol, after the 8 ° C and 11 ° C cryotherapy, the muscle activities were recorded during both walking and running.

Cryotherapy

In the present study, a fully automatic cooling device at different temperatures performed cryotherapy. This device is researcher-made. Predicted temperatures for cryotherapy were 8 ° C and 11 ° C (Figure 4).

Figure 4. Fully automatic cooling device

Statistical analysis

The normality of the data distribution was confirmed by Shapiro-Wilk test. ANOVA with repeated measure test was used for statistical analysis. All analyzes were performed at the significant level of 0.05 using SPSS 24 software.

Results

The normality of the data distribution was confirmed by Shapiro-Wilk test (Table 1).

Table 1: Shapiro-Wilk test

muscles	walking		running	
	Statistic	Sig.	Statistic	Sig.
TA	0.973	0.817	0.937	0.210
GC	0.939	0.234	0.945	0.292
VL	0.936	0.205	0.962	0.576
VM	0.986	0.988	0.948	0.335
RF	0.971	0.768	0.944	0.287
BF	0.916	0.084	0.917	0.087
ST	0.972	0.805	0.963	0.609
GM	0.944	0.928	0.924	0.198

During walking, frequency spectrum of rectus femoris muscle after 11 ° C cryotherapy was greater than before fatigue during walking by 16.43% (p=0.047) (Table 2). Frequency spectrum of semi-tendentious muscle after 11 ° C cryotherapy was higher than before fatigue during walking by 38.11% (p=0.044) (Table 2).

Table 2. Comparison of the mean and standard deviation of frequency spectrum of lower limb muscles before and after fatigue, and after cryotherapy at different temperatures during walking.

Muscle	Pre-test	Post-test			P-value			
		No temperature	8 C°	11 C°	P*	P●	P°	P$
TA	91.47±12.06	91.40±12.80	98.08±13.44	92.45±10.88	1.000	1.000	1.000	1.000
GC	82.45±13.10	93.03±16.34	90.88±17.31	86.69±8.43	0.094	0.555	1.000	1.000
VL	72.33±23.79	74.80±30.14	70.29±12.23	74.06±33.85	1.000	1.000	1.000	1.000
VM	78.48±32.31	77.80±13.97	97.37±33.54	86.65±27.41	1.000	0.916	1.000	1.000
RF	**69.10±17.32°**	80.07±21.73	82.51±20.66	**80.46±17.52°**	1.000	0.715	**0.047**	1.000
BF	78.26±12.72	77.21±18.69	85.44±14.03	75.39±5.96	1.000	1.000	1.000	0.742
ST	**72.47±31.79°**	74.96±15.47	97.32±29.89	**100.09±22.27°**	1.000	0.109	**0.044**	1.000
GM	73.86±23.61	75.92±15.33	72.20±22.05	73.14±12.86	1.000	1.000	1.000	1.000

* Significant difference between pre and after fatigue, ●Significant difference between pre-test and after 8 ° C cryotherapy, ° Significant difference between pre-test and after 11 ° C cryotherapy, **$** Significant difference between 8 ° C and 11 ° C cryotherapy

Frequency spectrum of rectus femoris muscle after fatigue at 8 ° C was higher than before fatigue during running by 28.56% (p=0.031) (table 3).

Table 3. Comparison of the mean and standard deviation of frequency spectrum of lower limb muscles before and after fatigue, and after cryotherapy at different temperatures during running.

Muscle	Pre-test	Post-test			P-value			
		No temperature	8 C°	11 C°	P*	P●	P°	P$
TA	88.74±18.09	87.76±13.70	94.70±9.98	89.64±14.09	1.000	1.000	1.000	1.000
GC	82.75±15.19	89.28±22.25	93.90±24.28	86.32±20.55	1.000	0.101	1.000	0.123
VL	72.72±9.72	81.48±16.15	78.36±16.37	80.27±13.80	0.788	1.000	1.000	1.000
VM	77.93±19.97	66.31±16.50	75.96±18.40	90.82±19.40	0.634	1.000	0.603	0.307
RF	**77.74±15.13●**	80.21±26.60	**99.95±●25.64**	78.06±11.39	1.000	**0.031**	1.000	1.000
BF	66.86±13.90	67.07±16.10	78.96±17.05	73.51±7.11	1.000	0.768	0.498	1.000
ST	56.97±8.77	60.44±9.57	75.56±11.12	68.55±21.68	1.000	0.084	0.332	1.000
GM	64.16±12.58	61.37±11.58	78.51±17.81	66.73±14.47	1.000	0.408	1.000	1.000

* Significant level between pre and after fatigue, ●Significant level between pre-test and after 8 ° C cryotherapy, ° Significant level between pre-test and after 11 ° C cryotherapy, **$** Significant level between 8 ° C and 11 ° C cryotherapy

Discussion

The purpose of the present study was to investigate the effect of using cryotherapy on frequency spectrum of lower limb muscles during running and walking before and after muscular fatigue.

The results of the present study are inconsistent with the results of Hosseini et al. (2016) (23). Hosseini et al show that cryotherapy reduces the frequency of rectus femoris muscle after fatigue. It has also been reported that cryotherapy improves pain threshold, viscosity, and plastic deformation of tissues, while reducing motor function (24). Fischer et al. (24) showed that cryotherapy reduces muscle activity, which may increase the risk of injury after the athlete again returns to competition. These results are based on the negative effects on nerve potential conduction velocity and synaptic transmission and impairment in physical function during maximum-intensity functional tasks (25). Nasser pour & Sadeghi (2017) stated that the use of cryotherapy in the short term can significantly reduce skin temperature without directly affecting the muscles, in these cases, most studies reported increased muscle strength (26). The present results are in line with the results of Johnson et al., (27). Past research has shown that cryotherapy can raise blood pressure and heart rate, which in turn releases norepinephrine, a type of stress hormone and a neurotransmitter. When the muscle cools down, it automatically decreases blood flow by contracting blood vessels. When cryotherapy is stopped, the vessels return to normal. In result, blood has more anti-inflammatory protein than before, which can be very effective after fatigue and the affected areas. In accordance with our results, it seems that using cryotherapy after fatigue may improve muscle function during different activities.

The present study has some limitations such as lack of female gender in the statistical sample and self-selection speed while running and walking. On the other hand, lack of kinematics and kinetics recording was another limitation of this study.

Conclusion

It seems that using cryotherapy after fatigue may improve muscle function during different activities.

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چکیده فارسی

بررسی اثر استفاده از روش سرمادرمانی جدید بر طیف فرکانس عضلات اندام تحتانی طی دویدن و راه رفتن

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سرما درمانی یکی از فاکتورهای مهم در بهبود عملکرد عضلات بعد از خستگی می‌باشد. لذا هدف از پژوهش حاضر بررسی اثر استفاده از سرمادرمانی بر طیف فرکانس فعالیت الکتریکی عضلات اندام تحتانی طی دویدن و راه رفتن قبل و بعد از خستگی بود. پژوهش حاضر از نوع نیمه تجربی بود. ۱۰ فوتبالیست مبتدی مرد به صورت داوطلبانه شرکت کردند. از یک سیستم الکترومایوگرافی بدون سیم با ۸ جفت الکترود سطحی برای ثبت فعالیت الکترومایوگرافی عضلات اندام تحتانی قبل و بعد از خستگی در دمای ۸ و ۱۱ درجه سانتی‌گراد طی دویدن و راه رفتن استفاده شد. طیف فرکانس عضله راست رانی بعد از خستگی در دمای ۱۱ درجه سانتیگراد در مقایسه با قبل از خستگی طی راه رفتن ۱۶/۴۳ درصد بیشتر بوده است (p= ۰/۰۴۷). طیف فرکانس عضله نیمه وتری بعد از خستگی در دمای ۱۱ درجه سانتیگراد در مقایسه با قبل از خستگی طی راه رفتن ۳۸/۱۱ درصد بیشتر بوده است (p= ۰/۰۴۴). به‌علاوه طیف فرکانس عضله راست رانی بعد از خستگی در دمای ۸ درجه سانتیگراد در مقایسه با قبل از خستگی طی دویدن ۲۸/۵۶ درصد بیشتر بوده است (p= ۰/۰۳۱). سرمادرمانی باعث افزایش طیف فرکانس الکترومایوگرافی در دمای ۱۱ درجه سانتیگراد در عضله نیمه‌وتری و راست رانی طی راه رفتن و افزایش طیف فرکانس الکترومایوگرافی در دمای ۸ درجه سانتیگراد در عضله راست رانی طی دویدن گردید. به نظر می‌رسد استفاده از سرمادرمانی به کارگرفته در تحقیق حاضر بعد از خستگی می‌تواند باعث بهبود عملکرد عضلات طی فعالیت‌های مختلف گردد.

واژه‌های کلیدی: دستگاه سردکننده تمام اتوماتیک، الکترومایوگرافی، خستگی، دویدن