Effects of Cooling on Ground Reaction Forces, Knee Kinematics, and Jump Height in Drop Jumps

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ABSTRACT

This study investigated the effect of knee joint ice application on vertical ground reaction forces (VGRF), knee angle (KA), and jump height (JH) during a single-leg drop jump in 20 healthy participants randomly assigned to an experimental or control group. VGRF were measured using a force plate, KA was measured using an electrogoniometer, and JH was derived from VGRF. After the pretests, a crushed-ice bag was applied to the experimental group participants for 20 minutes, whereas the control group rested. All participants were retested immediately and again after 20 minutes of rest. Significant decreases in average braking phase VGRF (–0.18±0.14 body weight) and increases in contact time (51±39 ms) were found after icing. In addition, several nonsignificant trends toward force reduction were identified. These findings support the statement that when athletes return to competition after icing, an altered neuromuscular behavior might lead to potential re-injury situations.

Cryotherapy, especially the use of crushed-ice packs, is a widely accepted and commonly applied method for the immediate treatment of pain following an injury during sporting events. Athletes often return to competition after treatment because of the reduction in pain.

In addition to its positive effects on pain, cryotherapy is also known to cause decreases in edema,[1,2] inflammation,[2] muscle blood flow,[3] intramuscular temperature,[1,4] muscle spasm,[1] and nerve conduction velocity.[5] In addition, muscle and joint cooling can lead to diminished functional performance in movement tasks such as shuttle running,[6-8] sprinting,[8] hopping,[6] and jumping.[6-9]

In contrast, several studies have shown no effect or positive effects of cryotherapy on reflex responses,[10] weight discrimination,[11] ankle joint kinematics during a side-stepping maneuver,[12] and muscle activity during maximal voluntary isometric contractions.[13] Given this controversial body of evidence, the effects of cryotherapy seem to be highly dependent on the intensity of the movement task—for instance, more negative effects are seen in high-impact exercises involving high velocities, such as plyometrics.[14]

We previously showed that the use of a 20-minute crushed-ice pack application to the knee joint tended to decrease the electromyographic (EMG) activity of the following muscles when performing a single-leg drop jump exercise: biceps femoris (BF) and the medial head of gastrocnemius (MG) during the preactivation phase (100 ms prior to landing); vastus medialis (VM) and lateralis (VL), BF, MG, tibialis anterior (TA), and peroneus longus (PL) during the eccentric (braking) phase; and VL, rectus femoris (RF), and MG during the concentric (push-off) phase.[14] We speculated that diminished proprioception could have resulted in a modification of muscle activity during the prelanding and braking phases, leading to a reduced storage of elastic energy in the tendinous tissue and therefore a decrease in performance during the push-off phase.

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TABLE 1

Definitions of the Dependent Variables

VARIABLE	DEFINITION
Fmax	Impact peak force (in BW)
Fint_1	Braking impulse (in BW), determined by integrating the normalized braking phase VGRF over time
Fint_2	Push-off impulse (in BW), determined by integrating the normalized push-off phase VGRF over time
Favg_1	Average braking force (in BW)
Favg_2	Average push-off force (in BW)
RFD	Rate of force development (in BW/s), calculated as the slope of the VGRF trace from T1 to 80% of Fmax
KA_Landing	Knee angle (in °) at T1
KAmax	Maximum knee angle (in °) between T1 and T3
KA_Takeoff	Knee angle (in °) at T3
t_KAmax	Time (in ms) from T1 to KAmax
t_Fmax	Time (in ms) from T1 to Fmax
t_Contact	Total contact time (in ms)
JH	Jump height (in % of body height), calculated according to the following formula (where g is 9.81 m/s^2 and t_Jump is the time between T3 and T4): $$JH = \frac{\frac{\left(\frac{1}{2}\ t\_Jump \text{ X } g\right)^2}{2 \text{ X } g}}{BH} \text{ X } 100\%$$

Abbreviations: BW, body weight; VGRF, vertical ground reaction forces; T1, first moment of touch down; T3, push-off moment; T4, second moment of touch down.

However, because no analyses on biomechanical (eg, force generation) and performance measurements (eg, height of a jump) were conducted, this statement was solely based on previous research. Kinzey et al,[9] for example, reported a decrease in total vertical impulse that lasted for approximately 10 minutes by investigating the vertical ground reaction forces (VGRF) during 25 one-legged vertical jumps following a 20-minute ice bath immersion.

Therefore, the purpose of the current study was to investigate the immediate effect of a 20-minute crushed-ice pack application to the knee joint, as well as the effect after another 20 minutes of rest following the ice application on VGRF, sagittal plane knee kinematics, and jump height (JH) in a single-legged drop jump exercise. Based on the previously published results on EMG,[14] it was hypothesized that the ice application would cause a decrease in biomechanical (decreases in VGRF and maximal knee flexion angle) and performance measures (decrease in JH and increase in contact times) immediately after the application and after another 20 minutes of rest. Due to a lack of evidence on the reliability of such performance measurements during drop-jump exercises, our study also aimed to identify the highest intrasession reliability over 3, 4, and 5 jumps, as well as the test–retest (intersession) reliability of 3 testing sessions.

METHOD

Design

Two separate 2×2 (group × time) multivariate repeated measures analyses of variance (ANOVAs) guided the study. Groups were control and ice (experimental). The separate designs involved different repeated measures of time. The first design included the pretest and, immediately after ice removal, posttest; the second design included the pretest and, 20 minutes after ice removal, posttest. Dependent variables are listed in Table 1.

Participants

A convenience sample of 20 healthy men and women, aged between 23 and 40 years, were recruited to participate in this study. Inclusion criteria were that participants had full range of motion and normal strength in their lower extremities; did not experience any orthopedic injury, musculoskeletal, or neuromuscular diseases, disorders, or conditions within the year prior to the tests; and had no history of surgery to their lower extremities. In addition, all participants had to be able to perform a single-leg drop jump from a drop height of 30 cm based on a previously described procedure.[14] To verify the inclusion criteria, the participants performed 20 unloaded, full range-of-motion squats; 25 unloaded, full range-of-motion single-leg heel raises; and 1 single-leg drop jump from a drop height of 30 cm above the ground. In addition, the intactness of the dorsalis pedis pulse and skin surface sensation (according to the dermatomes) were evaluated as inclusion criteria for safety purposes. Participants were randomly assigned to an experimental (8 men, 2 women; mean age = 28.7±5.5 years; mean height = 1.78±0.1 m; mean body mass = 76.3±11.8 kg) and a control group (5 men, 5 women; mean age = 28.7±4.0 years; mean height = 1.72±0.1 m; mean body mass = 67.0±11.9 kg) using a randomized list and became aware of their group assignment only after the pretest (after the ice was prepared for them). The experimental protocol had been approved by the university's institutional review board, and all participants gave informed consent.

1

Figure 1. Custom-built electrogoniometer, attached to the lateral side of the knee joint of the dominant leg.

Instrumentation

A multicomponent force plate system (Type 9286A; Kistler, Winterthur, Switzerland) was used to measure the VGRF during the jumps. The signal was collected at a sampling rate of 1 kHz and amplified in a range of 5 kN per channel (External Control Unit Type 5233A; Kistler, Winterthur, Switzerland). The knee angle (KA) was measured using a custom-built electrogoniometer (Figure 1), which was attached to the lateral side of the knee joint of the dominant leg (sampling rate = 1 kHz). All measurements were obtained in a university research laboratory.

Procedures

The dominant leg was determined using the ball-kick test, step-up test, and balance-recovery test. The leg that was used most often (ie, for at least 2 of the 3 tests) to kick the ball, to step onto a step, and to recover balance was in each case identified as the dominant leg for this study. Following these tests, the participants practiced the jumping procedure up to a maximum of 10 jumps and performed a low-intensity, 5-minute warm-up program using a cycle ergometer. For the first test session (pretest), each participant jumped from a 30-cm high wooden box that was placed 3 cm from the force plate and, after ground contact with the dominant leg, rebounded immediately as high as possible (drop jump). The drop jumps were performed 5 times, with an approximate rest time of 30 seconds in between. Then, the participants in the experimental group were asked to lie down in a supine position and a crushed-ice bag (same dimension and filled with a similar quantity of ice for every participant) was placed on the anterior and medial area of the dominant limb's knee joint for 20 minutes. Laterally, the application area was limited by the electrogoniometer and did not cover the fibular head; thus, no major peripheral nerves were directly cooled. Within these limitations, the ice bag covered an area of 20 × 12 cm. To prevent skin damage, a dry, thin towel was placed between the ice pack and the skin. No compressive bandaging was applied to fix the bag to the knee to attain a similar level of cooling. The participants in the control group rested without any intervention. Immediately afterward, all participants performed the second test session (posttest 1) using the same protocol as in the pretest. Then, the participants were seated again and rested for 20 minutes before they performed the third test session (posttest 2). The electrogoniometer remained affixed across all measurements.

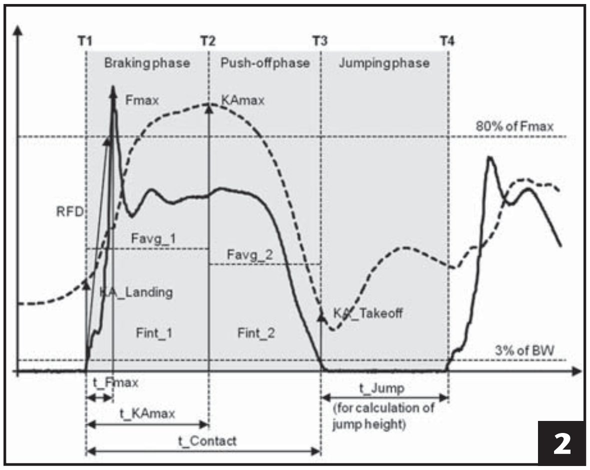

Figure 2. Segmentation and parameterization of the vertical ground reaction force (solid line) and knee angle (dotted line) curves. (See Table 1 for definitions of variables.)

Data Reduction

VGRF and KA curves (Figure 2) were digitally processed by applying a notch filter (59 to 61 Hz), as well as a 30-Hz lowpass filter (Butterworth, zero lag, 2nd order). The first VGRF data point that exceeded 3% of the participant's body weight (BW) was considered the first moment of touch down (T1). The data point that fell below 3% of BW after at least 100 ms of ground contact was considered the push off moment (T3). The second moment of touch down (T4) was defined as the point when the VGRF signal again exceeded 3% of BW (landing after the vertical jump). The point at which the maximum KA was noted between T1 and T3 was considered the moment when the knee changed from an eccentric to a concentric movement (T2). Considering these events, the following segments were defined: braking phase (T1 to T2), push-off phase (T2 to T3), and jumping phase (T3 to T4). After normalizing VGRF (in newtons) to BW, the curves were then parameterized into the dependent variables (Table 1). All data were collected and analyzed using a custom LabView program (version 8.6; National Instruments, Austin, Texas).

Statistical Analysis

All statistical calculations were performed using SPSS version 16 software for Windows (SPSS Inc, Chicago, Illinois), Microsoft Excel 2007 software (Microsoft Inc, Redmond, Washington), and CMA 2 software (Biostat Inc, Englewood, New Jersey).

Independent samples *t* tests with the α level set at 0.05 were used to compare principal confounders, such as age, height, and body mass, between the experimental and control groups, as well as to ensure the between-group homogeneity of the dependent variables at baseline. Kolmogorov–Smirnov tests were further used to verify a normal distribution of the dependent variables.

Reliability. ANOVAs with repeated measures were conducted to identify possible systematic errors among the trials within the pretest jumps, as well as among the test sessions (significant systematic error when $P \leqslant .05$). Intrasession reliability was calculated for the first third, fourth, and fifth trials within the pretest session of all 20 participants using the intraclass correlation coefficient (ICC) type (3,1) (ie, relative reliability) and the standard error of measurement (SEM) (ie, absolute reliability) using the following formula:

$$SEM = SD\sqrt{1 - ICC}$$

This 3-layered approach (repeated measures ANOVA, ICC, and SEM) was recommended by Weir[15] for a comprehensive assessment of reliability in the field of movement sciences. The results indicated the highest overall intrasession reliability for the first 3 jumps; therefore, all further calculations were based on the average values of the first 3 jumps of each test session. For the 10 control group participants, test–retest (intersession) reliability over the pretest, posttest 1, and posttest 2 sessions was calculated using the same protocol. It was previously noted that the effect of measurement error on correlation attenuation becomes minimal as ICCs increase above 0.8.[15] Therefore, ICCs $\geqslant$ 0.8 with respectively low SEMs were considered good reliability in the context of this study.

Effects of Knee Joint Cooling. To test the group $\times$ time interaction effects of the dependent variables, 2 separate 2 $\times$ 2 multivariate ANOVAs with repeated measures were conducted (pretest to posttest 1 and pretest to posttest 2). Bonferroni correction was applied, and significance was accepted at the $P \leqslant .025$ level. Standardized mean differences and 95% confidence intervals (CI) were additionally calculated for the pretest to posttest 1, as well as the pretest to posttest 2 effects and was graphically presented in form of a forest plot. Due to the low number of participants, this may be helpful with the interpretation of the effects that did not reach statistical significance.

TABLE 2

Descriptive Statistics of the Pretest (Pre), Posttest 1 (Post1) and Posttest 2 (Post2) Sessions and Results of Repeated Measures ANOVA (Group × Time Interaction Effects)

			PRE			POST1		POST2		ANOVA (*P*)	
VARIABLE[a]	UNIT	GROUP	MEAN	SD	*t* TEST (*P*)	MEAN	SD	MEAN	SD	PRE–POST1	PRE–POST2
Fmax	BW	No ice	3.45	0.65	.487	3.45	0.70	3.54	0.61	.154	.134
		Ice	3.25	0.63		2.99	0.77	3.01	0.64		
Fint_1	BW	No ice	0.35	0.07	.059	0.37	0.08	0.39	0.05	.738	.353
		Ice	0.41	0.07		0.42	0.07	0.43	0.08		
Fint_2	BW	No ice	0.31	0.04	.667	0.30	0.04	0.30	0.03	.260	.348
		Ice	0.32	0.06		0.33	0.04	0.33	0.04		
Favg_1	BW	No ice	1.85	0.21	.266	1.84	0.24	1.86	0.17	.019**	.051
		Ice	1.96	0.21		1.78	0.27	1.83	0.24		
Favg_2	BW	No ice	1.50	0.20	.095	1.49	0.18	1.50	0.14	.082	.489
		Ice	1.67	0.22		1.57	0.22	1.63	0.29		
RFD	BW/s	No ice	70.67	42.09	.223	73.68	49.82	70.79	34.79	.788	.907
		Ice	52.41	15.51		51.58	21.42	50.89	24.59		
KA_Landing	degree	No ice	23.40	10.71	.371	23.35	11.80	24.03	12.54	.790	.710
		Ice	28.01	11.73		27.44	9.32	27.77	8.47		
KAmax	degree	No ice	61.71	12.35	.292	61.56	10.95	62.71	10.62	.224	.489
		Ice	66.91	8.76		69.21	8.51	69.78	7.17		
KA_Takeoff	degree	No ice	11.90	15.40	.864	14.16	14.71	15.29	15.44	.450	.934
		Ice	12.88	8.80		12.95	9.55	16.02	7.77		
t_KAmax	ms	No ice	192	44	.311	206	45	213	25	.184	.821
		Ice	212	42		244	52	237	45		
t_Fmax	ms	No ice	58	22	.680	56	19	56	17	.569	.285
		Ice	62	11		61	16	64	15		
t_Contact	ms	No ice	402	52	.882	411	54	416	42	.018**	.283
		Ice	405	53		456	62	443	61		
JH	percent	No ice	6.03	2.34	.016*	5.83	2.07	6.20	2.11		
		Ice	9.24	3.04		8.75	1.69	8.93	2.53		

[a] See Table 1 for definitions of variables.
* Indicates statistically significant difference ($P \leq .05$).
** Indicates statistically significant interaction ($P \leq .025$).

RESULTS

Group comparisons revealed no statistically significant differences for the principal confounders (age, height, and body mass) and confirmed the homogeneity of the baseline measures for all dependent variables except for JH (Table 2). Therefore, JH could not be considered for further evaluation. Kolmogorov–Smirnov tests further confirmed normal distribution for the dependent variables.

Reliability

All results of the reliability calculations are presented in Table 3. Repeated measures ANOVA revealed no systematic error for all variables within the first session, as well as over all 3 sessions. For the first 3 jumps of the pretest session (intrasession reliability), all variables showed ICCs > 0.8 with respectively low SEMs except Fint_1, Fint_2, and RFD (ICCs between 0.269 and 0.788 with respectively

TABLE 3

Intrasession[a] and Intersession[b] Reliability Calculations

		INTRASESSION RELIABILITY				INTERSESSION RELIABILITY			
VARIABLE[c]	UNIT OF MEASURE	MEAN	SD	ICC	SEM	MEAN	SD	ICC	SEM
Fmax	BW	3.35	0.67	0.808	0.29	3.03	0.22	0.683	0.12
Fint_1	BW	0.38	0.08	0.788	0.04	0.40	0.03	0.690	0.02
Fint_2	BW	0.32	0.07	0.269	0.06	0.27	0.03	0.626	0.02
Favg_1	BW	1.91	0.22	0.816	0.09	1.78	0.11	0.755	0.05
Favg_2	BW	1.59	0.23	0.881	0.08	1.49	0.05	0.827	0.02
RFD	BW/s	61.54	34.33	0.788	15.81	38.76	2.00	0.589	1.29
KA_Landing	degree	25.70	11.21	0.947	2.58	35.56	1.59	0.955	0.34
KAmax	degree	64.31	10.88	0.927	2.94	74.94	5.77	0.900	1.82
KA_Takeoff	degree	12.39	12.21	0.957	2.53	29.72	4.13	0.952	0.91
t_KAmax	ms	202	45	0.817	19	228	27	0.620	17
t_Fmax	ms	60	18	0.872	6	73	1	0.886	0
t_Contact	ms	404	54	0.804	24	410	48	0.670	28
JH	percent	7.72	3.14	0.944	0.74	3.90	0.57	0.877	0.20

Abbreviations: SD, standard deviation; ICC, intraclass correlation coefficient type (3,1); SEM, standard error of measurement; BW, body weight.
[a] First 3 jumps of all 20 participants in the pretest session.
[b] Averages of first 3 jumps of each of the 3 test sessions for the 10 control participants.
[c] See Table 1 for definitions of variables.

high SEMs). For intersession (test–retest) reliability, only the variables Favg_2, KA_Landing, KAmax, KA_Takeoff, t_Fmax, and JH revealed ICCs > 0.8 with respectively low SEMs. The variables Fmax, Fint_1, Fint_2, RFD, t_KAmax, and t_Contact indicated fair ICCs (0.589 to 0.690) but also considerably low SEMs (see Table 1 for variable definitions).

Effects of Knee Joint Cooling

The analysis of the effect of cryotherapy indicated statistically significant interactions between the pretest and posttest 1 sessions and the groups for the variables Favg_1 ($P = .019$) and t_Contact ($P = .018$). Given the standardized mean differences and 95% CIs presented in Figure 3, the variables Favg_1 and Fmax indicated considerable nonsignificant trends toward force reduction between the pretest and posttest 2 sessions and the groups. Another considerable nonsignificant trend toward force reduction was found for the variable Favg_2 between the pretest and posttest 1 sessions and the groups. All other variables were considered to show no meaningful effects or trends due to knee joint cooling.

DISCUSSION

Reliability

The intrasession reliability was considered good (ie, ICCs > 0.8 and low SEMs) for most of the variables except Fint_2 (ICC = 0.269, SEM = 0.06 BW) and RFD (ICC = 0.788, SEM = 15.81 BW/s). A possible explanation for the only moderate reliability of RFD could be the sensitive underlying algorithm. Only a small change in the landing strategy could result in considerable changes in RFD. Therefore, the observed moderate reliability might be due to the physiologic variability of the movement. However, we could not find any plausible explanation for the low ICC of Fint_2. Fint_1 showed only an ICC of 0.788 but also a low SEM (0.04 BW) and was therefore considered moderately reliable. In terms of intersession (test–retest) reliability, the variables Favg_2, KA_Landing, KAmax, KA_Takeoff, t_Fmax, and JH showed good reliability, with ICCs > 0.8. All other variables (Fmax, Fint_1, Fint_2, Favg_1, RFD, t_KAmax, and t_Contact) revealed ICCs < 0.8 but were still considered moderately reliable because of their distinctly low SEMs.

Ortiz et al[16] also investigated the intrasession reliability of the VGRF in single-legged drop jumps and found

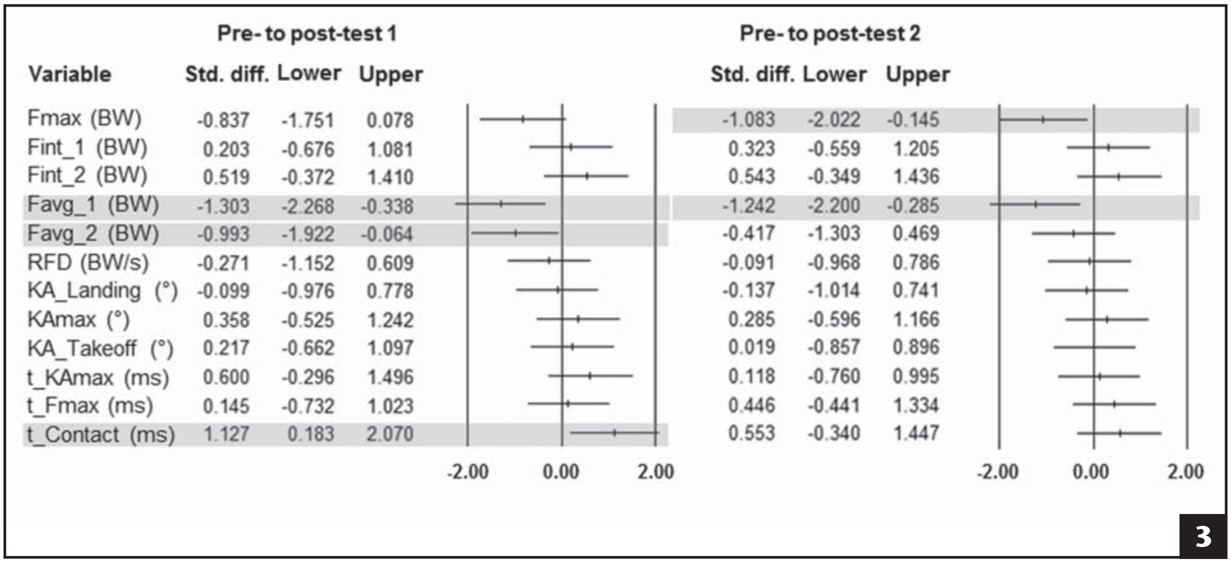

Figure 3. Standardized mean differences (std. diff.) and 95% confidence intervals (Lower = lower limit; Upper = upper limit) between the experimental and control groups (pretest to posttest 1 and pretest to posttest 2 values) for all dependent variables except jump height. See Table 1 for definitions of variables.

ICCs of 0.86 for peak VGRF and 0.85 for total contact time for a test set of 3 jumps. Although their experimental conditions were slightly different (eg, drop height of 40 cm), it appears that studies evaluating drop jumps from a drop height between 30 and 40 cm should not include more than 3 test trials. Therefore, we recommend the combination of 10 practice trials and 3 test trials for the reliable measurement of VGRF in drop jumps.

Effects of Knee Joint Cooling

The hypothesis that functional performance would decrease after a 20-minute, cold-pack ice application and that the effects would persist after another 20 minutes of rest was not supported by the results, as we were unable to analyze jump height. However, average braking force and total contact time of the jump performance were significantly reduced immediately after icing (Table 2, Figure 3) but were no longer significantly different from the pretest after 20 minutes of rest. In addition, we believe the standardized mean differences and 95% CIs (Figure 3) allow for the interpretation of further changes as clinically meaningful. Therefore, clinically meaningful trends toward force reduction could be identified for average push-off force immediately after ice removal, as well as for maximum force and average braking force between the pretest and after 20 minutes of rest.

In comparison with prior investigations, the general findings of the current study agreed with those of other studies that found potentially negative effects of cryotherapy on functional performance measures such as shuttle run and 6-m hop test,[6] agility shuttle run and 40-yard sprint,[8] co-contraction test and shuttle run test,[7] and selected VGRF parameters.[9] Kinzey et al[9] investigated the effect of a 20-minute cold whirlpool immersion on the average VGRF, peak VGRF, and vertical impulses during 5 sets (1 before and 4 after whirlpool immersion) of single-legged vertical jumps. The results revealed no decreases in the average VGRF but showed considerable decreases in the vertical impulse, as well as in the peak VGRF. The authors concluded that one should wait approximately 15 minutes before engaging in activities that require the production of weight-bearing explosive strength or power following a cryotherapy application.

In the current study, the decreases in average and maximum force, as well as the increase in total contact time, indicated that a “softer” landing and a more cautious push-off strategy was supported by the previously reported decreased VM and VL muscle activation during the braking phase and by decreases in VM and RF muscle activation during the push-off phase.[14] However, the ice application had little effect on the braking and push-off impulses. Therefore, it seems that cryotherapy caused an alteration in the neuromuscular strategy rather than a direct decrease in functional jumping performance.

One possible mechanism to achieve a softer landing could be to increase the ankle, knee, or hip flexion angles. In the current study, maximum knee flexion did not show an increase after the ice application; we did not measure ankle and hip kinematics. However, results from our previous study[14] demonstrated that icing caused changes in the neuromuscular strategy of landing because the VM, VL, BF, and MG muscles decreased their activity during the braking phase. Because the BF plays a role in hip extension and the MG plays a role in ankle plantarflexion, reduced activity may have caused more flexion at the hip and dorsiflexion at the ankle. The combined effect of reduced muscle activity of muscles surrounding the knee[14] and the reduction in forces and increase in total contact time (current study) after icing suggests that the softer landings were accomplished via other kinematic changes outside the knee. However, more research is recommended to verify these suggested kinematic changes.

Limitations

Several limitations of the experimental protocol were previously discussed.[14] In brief, the limitations included the following: the thin towel that was put between the ice pack and the skin to prevent skin damage did not simulate the playing field environment; skin temperature measurement was lacking; the participants were healthy, rather than injured; and the participant sample was small. Further limitations included the facts that JH featured heterogeneity of the baseline measures and was therefore excluded from the interpretation, no measurements of ankle and hip kinematics were included, and the amount of ice was not quantified by measuring its mass. In addition, there was gender inequality in the experimental group (8 men, 2 women), whereas the genders in the control group were equally distributed (5 men, 5 women).

In real injury situations, it is common to affix the ice bag to the knee with the aim of increasing the effect of the ice. Because the compression in the current study was simply induced by gravity, it is questionable whether the results can be directly applied to a real situation.

IMPLICATIONS FOR CLINICAL PRACTICE

The findings of the current study support the statement that when athletes return to competition after icing, an altered neuromuscular behavior might lead to potential re-injury. Athletic trainers should be aware of this fact and consider a time-out for athlete's, lasting approximately 20 minutes, before engaging them in activities that require weight-bearing, explosive strength production.

CONCLUSIONS

Twenty minutes of knee joint cooling tended to decrease the average VGRF values of the braking and push-off phases, maximum force, and total contact time. Maximum knee angle and the braking and push-off impulses were not affected by the ice application. Therefore, we speculate that functional performance was unchanged because the ankle or hip joint might have increased flexion angle to compensate for the diminished activity of the weight-bearing knee joint muscles. These findings support previous research, which suggests that when athletes return to competition after an ice application, the altered neuromuscular behavior might lead to potential re-injury situations,[17] especially when there is no obvious change in functional performance. Future studies should evaluate kinematics of the entire lower extremity and the trunk (at a minimum in the sagittal plane) and should contain a more representative intervention design (eg, icing for 30 minutes, wrapping of the ice pack, and without a towel between the ice pack and skin). Our reliability analysis suggests that most of the variables demonstrated moderate to good intrasession and intersession reliability. ■

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