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EFFECT OF HYDROTHERAPY, ACTIVE AND PASSIVE RECOVERY ON REPEATED MAXIMAL CLIMBING PERFORMANCE

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SUMMARY

The aim of the study was to compare the effect of four recovery methods (PAS – passive, ACT – active, CW – cold water, CWW – cold and warm water) on repeated climbing performance.

Five advanced climbers (mean age 28.6, *s* = 4.0 years) performed, in a random cross-over design, 4 sessions with 3 repeated climbing tests to exhaustion. The effect of the recovery methods on climbing performance (number of movements, climbing time), heart rate and grip strength was assessed by 4 × 3 repeated-measure ANOVA (recovery method × climbing test number). Significant interaction between recovery and the climbing test number for climbing performance was found (number of climbing movements: $F_{6,32} = 2.23$; $p = 0.07$; $\eta^2 = 0.30$; climbing time $F_{6,32} = 2.90$; $p = 0.02$; $\eta^2 = 0.35$). The decrease of performance between the 1st and 3rd test was after PAS 41%, CWW 24%, CW 0% and ACT 14% of the number of climbing movements. The recovery method did not have any effect on grip strength. The average decrease in grip strength was 30% after climbing and was significantly correlated with the number of climbing movements ($r = 0.80$) and climbing time ($r = 0.72$). The results demonstrated that ACT recovery and CW immersion are two means to maintain subsequent climbing performance to exhaustion.

Keywords: hydrotherapy, recovery, sport climbing, climbing performance

INTRODUCTION

Sport climbing and especially indoor climbing has risen in popularity in the last 20 years. Two main disciplines dominate sport climbing: lead climbing and bouldering. Lead climbing is climbing with a rope on natural or artificial terrain with preplaced “anchors” where the climber clips his or her rope through karabiners. The fall in lead climbing depends on the distance between bolts, but should not be dangerous. Bouldering is climbing on stones or artificial walls low over the ground without a rope. Both disciplines have international systems of competitions. The most “prestigious” discipline is, however lead climbing.

During lead climbing, in competition or in "rock climbing", repetitive performance is required. The recovery between trials is often incomplete and climbers start a new climbing route only partially recovered.

To date, only three studies (Draper, Bird, Coleman, & Hodgson, 2006; Heyman, De Geus, Mertens, & Meeusen, 2009; Watts, Daggett, Gallagher, & Wilkins, 2000) have investigated recovery in rock climbing. The studies of Draper et al. (2006) and Watts et al. (2000) stated that active recovery hastened blood lactate decrease within 2 to 20 min after intense climbing. Blood lactate, however, is not a suitable indicator of muscle fatigue (Barnett, 2006). The acidosis has little effect on muscle contraction at physiological temperature and has even been shown to have protective effects (D. Allen & Westerblad, 2004; Cairns, 2006). The effect of four recovery methods (active, passive, electrostimulation and cold water immersion) on performance was compared by Heyman et al. (2009). The study confirmed a faster decrease in blood lactate concentration after active recovery and cold water immersion and the results showed a sustainment of climbing performance after active recovery and cold water immersion. The study underlined the efficiency of cold water immersion and active recovery. However, the large variability in pre-test climbing performances makes the conclusions ambiguous.

Hydrotherapy is commonly used in sport practice to enhance recovery from exercise (Barnett, 2006; Ingram, Dawson, Goodman, Wallman, & Beilby, 2009; Wilcock, Cronin, & Hing, 2006). Cold water immersion and contrast water therapy are effective in minimising the physiological and functional deficits associated with delayed onset of muscle soreness (Vaile, Halson, Gill, & Dawson, 2008). The effect on subsequent performance is not clear (Montgomery et al., 2008).

The aim of the study was to compare the effect of four recovery methods (PAS – passive, ACT – active, CW – cold water, CWW – cold and warm water) on repeated climbing performance.

PROCEDURES

Participants

Five advanced climbers with climbing performance 7a–7c on the French scale (mean age 28.6, s = 4.0 years; body mass 67.1, s = 6.1 kg; height 1.77, s = 0.07 m; mean climbing experience 7.0, s = 2.4 years) took part in the study. All participants were requested to abstain from any strenuous physical activity 24 hours before testing.

Testing

Every climber underwent anthropometric measurement and an incremental maximal treadmill test to determinate heart rate (HR) max. Climbers then came to a climbing center to perform an 18 movement technically simple boulder on a 45 degrees overhanging climbing wall. The starting hold was also the final one and the boulder formed a circle. The speed of climbing was individual but climbers were asked not to stop on a hold for more than 3 seconds. A first climbing session was included to enable climbers to learn all movements. Then, climbers took part in 4 other sessions divided by 48 hours. The session proceeded in the same order. After the individual warm-up, the climber performed three climbs to exhaustion with a randomly assigned recovery lasting for 20 minutes. Climbing performance was assessed by the number of movements on the wall and climbing time.

Recovery methods

Four types of recovery were used (ACT, CW, CWW and PAS). PAS consisted of sitting on the bench near the climbing wall. During the ACT, climbers had to walk on the treadmill at a constant 5 km h^{-1} speed. The inclination of the treadmill was set individually so that the participants maintained their HR between 60–65% of HR max. Immersion in CW and CWW was performed by submerging arms and forearms in a tube of water set before the climbers on a bench. Hands were held outside the water. The CW was maintained at 13 ± 1 °C and the warm water at 37 ± 1 °C by adding ice cubes or hot water. The CW involved 3 times 4 minutes submerging arms and forearms separated by 2 minutes outside the water. The CWW consisted of submerging arms and forearms for 1 minute in cold water and 3 minutes in warm water. This procedure was repeated 4 times.

Grip strength and HR measurement

The calibrated hand dynamometer Takei TKK 5401 (Takei Scientific Instruments, Tokyo, Japan) was used for this test. The tested person, in a sitting position, grasped the hand dynamometer by the dominant hand and gradually applied maximal pressure. The pressure was graduated for at least two seconds. After recording the result, the non-dominant hand was measured. During the grasp the stretched hand was not allowed to touch any part of the body. The moveable part of the handle was adjusted to reach the first phalanx of the ring-finger. Two attempts were made and the best result for both hands was recorded with accuracy 0.1 kg. To eliminate right/left dominance, we counted the mean of the best right and left hand grip.

HR was recorded by the HR analyzer (Polar RS 400, Finnland) in all climbing attempts. Mean heart rate HR_{avg} and maximal heart rate HR_{max} were evaluated.

Statistical analysis

Statistics were computed using the statistical software SPSS for Windows Version 18.0. Normality was tested using Kolmogorov-Smirnov tests. The equality of errors variances was checked by Levene's test. The effect of the recovery methods on climbing performance (number of movements, climbing time), HR and grip strength was assessed by 4 × 3 repeated-measure ANOVA (recovery method × climbing test number). The statistical significance of α-level was set to 0.1 because of the low number of participants and η^2 was used to assess the percentage of explained variance by the factor. The Pearson coefficient of correlation was used to determine the relationship between grip strength and climbing performance.

RESULTS

A significant interaction between recovery and climbing test number for climbing performance was found (number of climbing movements: $F_{6,32} = 2.23$; $p = 0.07$; $\eta^2 = 0.30$; climbing time $F_{6,32} = 2.90$; $p = 0.02$; $\eta^2 = 0.35$). Figure 1 shows a decrease of climbing movements and climbing time for PAS and CWW recovery and a stable performance after CW and ACT recovery. There was no significant effect on handgrip strength before ($F_{6,32} = 0.66$; $p = 0.68$; $\eta^2 = 0.11$) and after climbing ($F_{6,32} = 0.50$; $p = 0.81$; $\eta^2 = 0.09$). Figure 2 shows slightly higher grip strength after climbing in the PAS group. Table 1 shows the mean and maximal HR during climbing. There was no significant effect of recovery on HR_{max} ($F_{6,32} = 1.63$; $p = 0.17$; $\eta^2 = 0.24$), which indicates similar physiological exhaustion for all trials.

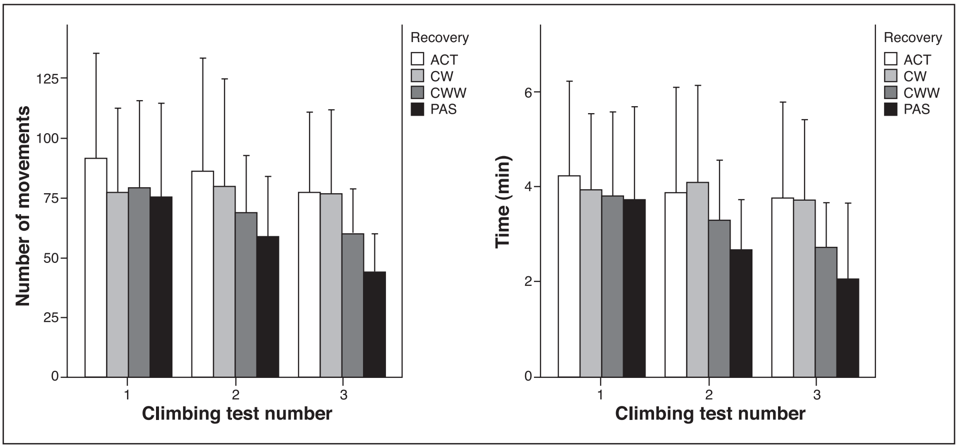

Figure 1. Climbing performance – number of movements and climbing time in 4 recovery methods (ACT – active, CW – cold water immersion, CWW – cold and warm water immersion, PAS – passive)

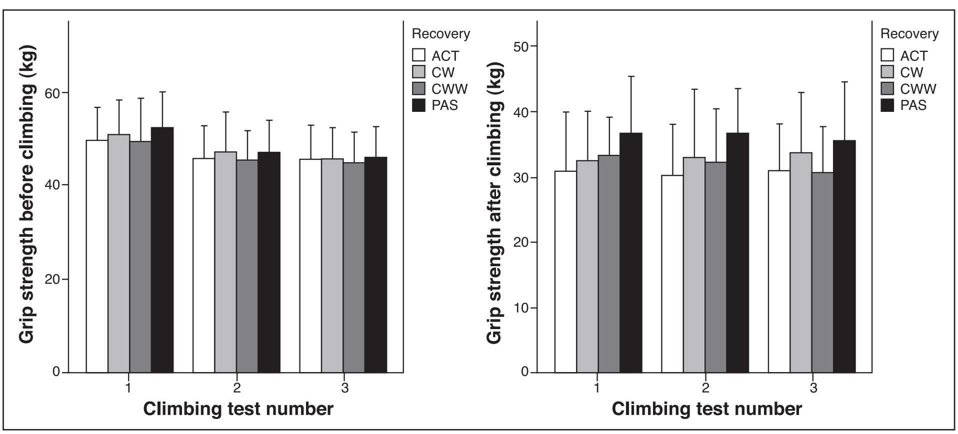

Figure 2. Grip strength before and after climbing in 4 recovery methods (ACT – active, CW – cold water, CWW – cold and warm water, PAS – passive)

Table 1. Mean and maximal heart rates (HR) (±*s*) during climbing after different types of recovery

	Climbing test number	ACT	CW	CWW	PAS
HR_{avg} (bpm)	1	147 ± 16	151 ± 16	146 ± 14	156 ± 17
	2	148 ± 12	150 ± 15	148 ± 16	153 ± 15
	3	146 ± 12	150 ± 15	147 ± 16	150 ± 14
HR_{max} (bpm)	1	167 ± 16	169 ± 17	164 ± 20	174 ± 15
	2	167 ± 13	170 ± 17	167 ± 18	170 ± 11
	3	166 ± 13	171 ± 14	165 ± 17	168 ± 14
HR_{max} determined on treadmill 194 ± 10 bpm					

DISCUSSION

The aim of the study was to compare the effect of four recovery methods (PAS, ACT, CW, CWW) on repeated climbing performance (number of climbing movements, climbing time). The main finding was that CW and ACT were more effective than CWW and PAS. The most important decrease of repeated performance was after the PAS.

The participants included in the current study were well-conditioned and experienced climbers. The time of climb approximately 3 to 5 minutes, corresponds to exhaustion time in lead climbing (Giles, Rhodes, & Taunton, 2006; Watts, 2004). The HR_{max} during climbing was nearly 90% of HR_{max} determined on a treadmill test, which confirms the very high intensity of the test.

The decrease of performance between the 1st and 3rd test was after PAS 41%, CWW 24%, CW 0% and ACT 14% in number of climbing movements, indicating a high efficiency of CW on recovery in climbing. However, we have to point to slightly higher performance in the 1st test for ACT recovery trials and similar number of movements in the 3rd repetition for ACT and CW recoveries.

The recovery method did not have any effect on grip strength, as already stated by Heyman et al. (2009). The average decrease in grip strength was 30% after climbing and was significantly correlated with the number of climbing movements (r = 0.80) and climbing time (r = 0.72). This finding corresponds to the study of Watts et al. (1996) who stated a significant relationship (r = 0.70) between the decrease in strength and climbing time. The higher strength decrease in more performing climbers could be connected to several reasons: energy substrates depletion, muscle fibres recruitment, pronounced acidosis, ionic interactions (D. G. Allen, Lamb, & Westerblad, 2008; Cairns, 2006; Cairns & Lindinger, 2008).

The CW and ACT were the most efficient recovery methods in the current study confirming the results of Heyman et al. (2009). The ACT recovery was performed by walking at 65% of HR_{max} instead of the cycle ergometer used in the previous study. Walking was chosen because of easier accessibility in natural conditions. In climbing the most involved muscle groups are in the forearms and upper body (Wall, Starek, Fleck, & Byrnes, 2004). In the current study, the legs were mostly involved during the recovery. The effect of ACT recovery on post-exercise lactate removal is well documented but the effect on repeated performance is still discussed (Barnett, 2006; Watts, Daggett, Gallagher, & Wilkins, 2000). The negative impact of ACT recovery was often stated in between sessions, performances or with recovery periods exceeding 4 hours. Our results support that ACT recovery for 20 minutes hastened subsequent performance.

There were two hydrotherapy methods used in the present study. While the CW immersion maintained the subsequent performance, there was a decrease of performance after the CWW immersion. The results are consistent with the previous studies (Coffey, Leveritt, & Gill, 2004; Ingram, Dawson, Goodman, Wallman, & Beilby, 2009) that also found no significant post-exercise benefits to be associated with CWW. Conversely, Vaile et al. (2007) stated smaller strength losses after CWW immersion. CW immersion has been shown to produce locale vasoconstriction, decrease locale blood flow, therefore, reduce cell necrosis, oedema, slow cell metabolism, nerve conduction velocity and decrease perception of pain (Ingram, Dawson, Goodman, Wallman, & Beilby, 2009; Vaile, Halson, Gill, & Dawson, 2008). CWW has been suggested to increase lactate clearance, decrease oedema, increase blood flow, increase stimulation of the central nervous system or stimulate the blood vessels by repetitive vasodilatation and vasoconstriction (Cochrane, 2004; Vaile, Halson, Gill, & Dawson, 2008). However, Blekley et al. (2010) and Barnett (2006) pointed to contradictory research on hydrotherapy and requested further evidence to explain physiological principles of the method and support recovery strategies.

CONCLUSION

The ACT recovery and CW immersion were efficient methods to maintain subsequent climbing performance to exhaustion. There was a significant decrease of climbing performance after CWW immersion (24%) and PAS recovery (41%) and these two methods did not prove suitable for recovery after climbing to exhaustion. The decrease of maximum grip strength after climbing to exhaustion was in close relationship with the time of climbing and number of climbing movements. Despite several research studies, there is a loss of evidence to satisfactory explain physiological principles of the ACT recovery and hydrotherapy.

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VLIV HYDROTERAPIE, AKTIVNÍHO A PASIVNÍHO ZOTAVENÍ NA OPAKOVANÝ LEZECKÝ VÝKON

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SOUHRN

Cílem studie bylo posoudit vliv čtyř typů odpočinku (PAS – pasivní, ACT – aktivní, CW – studená voda, CWW – studená a teplá voda) na opakovaný lezecký výkon. Pět pokročilých lezců (průměrný věk 28.6, *s* = 4.0 let) podstoupilo podle náhodně křížového plánu čtyři měření s třemi opakovanými lezeckými testy do vyčerpání. Efektivita odpočinku na lezecký výkon (počet kroků, čas lezení), srdeční frekvenci a sílu stisku ruky byla posuzována 4 × 3 analýzou rozptylu s opakováním měření (typ zotavení × lezecký test). Byla shledána významná interakce mezi typem zotavení a lezeckým testem (počet kroků: $F_{6,32}$ = 2,23; p = 0.07; η^2 = 0,30; čas lezení $F_{6,32} = 2{,}90$; $p = 0{,}02$; $\eta^2 = 0{,}35$). Pokles výkonu mezi prvním a třetím lezeckým testem byl po PAS 41 %, CWW 24 %, CW 0 % a ACT 14 % lezeckých kroků. Typ zotavení neměl vliv na sílu stisku ruky. Průměrný pokles síly stisku ruky po lezení byl 30 % a byl v těsném vztahu s počtem lezeckých kroků ($r = 0{,}80$) a časem lezení ($r = 0{,}72$). Výsledky ukázaly, že ACT odpočinek a ponoření do studené vody jsou vhodné prostředky k udržení opakovaného lezeckého výkonu do vyčerpání.

Klíčová slova: hydroterapie, odpočinek, sportovní lezení, sportovní výkon

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