Water Immersion: Does It Enhance Recovery From Exercise?

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**Purpose:** To assess the effect that postexercise immersion in water has on subsequent exercise performance. **Methods:** A literary search and review of water-immersion and performance studies was conducted. **Results:** Seven articles were examined. In 2, significant benefits to performance were observed. Those 2 articles revealed a small to large effect on jump performance and isometric strength. **Practical Application and Conclusions:** It is possible that water immersion might improve recovery from plyometric or muscle-damaging exercise. Such a statement needs to be verified, however, because of the scarcity of research on water immersion as a recovery strategy. **Key Words:** performance recovery, hydrotherapy, contrast therapy

Sporting competitions put an athlete’s body under stress either over the short term in tournament-style events, regattas, and stage racing or over a longer term in competitions where athletes compete weekly (or more) over numerous weeks. Training for such events can also put an athlete’s body under stress. In these types of circumstances there might be inadequate time for athletes to recover to their optimal physiological and psychological status before the next bout of exercise. Enhancing the recovery process in such situations could provide a competitive advantage to the athletes. Athletes, trainers, and coaches use many different methods to improve recovery and subsequent performance after exercise. These range from rest and sleep to nutritional strategies such as supplementation, to physical modalities such as massage, active recovery, and stretching.2,3 Another method that is gaining popularity as a means to improve recovery is immersion in water.2,3 Anecdotally, numerous sporting bodies, coaches, and athlete-support services seem to recommend the use of water immersion, especially contrast therapy, to improve recovery. There appears to be limited evidence to substantiate the claim that water immersion improves performance recovery. Of the studies that have been conducted, the protocols used have varied considerably or have concentrated on the reduction

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of blood lactate accumulation rather than maintaining performance. This review evaluates the effect of water immersion on different types of performance.

Data throughout the review have been converted into percentage differences between prerecovery and postrecovery performance measures and recovery modes. Although most articles report recovery effects in relation to statistical significance, many sport-science articles are underpowered in terms of subject numbers and might report nonsignificance incorrectly as no effect. We therefore also report effects as Cohen effect sizes (ES) using Hopkins' scale of magnitude (trivial, 0 to 0.2; small, 0.2 to 0.6; moderate, 0.6 to 1.2; large, 1.2 to 2.0; very large 2.0 to 4.0; near perfect, >4.0).

**Water Immersion**

The use of water immersion (in a pool or water bath) as a method of recovery is gaining popularity. Four basic modes of water immersion can be performed: cold immersion, hot immersion, alternating-temperature immersion (contrast therapy), immersion in which the water temperature is neutral in relation to body temperature. The difference between these 4 types of application is the immersion temperature. Contrast therapy has become one of the more popular methods of athletic recovery. Most performance-immersion research articles, however, do not indicate whether any possible benefit to recovery resulted from hydrostatic pressure or water temperature. Because of the scarcity of research on water immersion and performance, these different modes of immersion will be discussed collectively in this review, so the water temperature used in the immersion studies could have some influence on our findings.

The duration of water immersion appears to vary among sport texts and teams that practice immersion recovery. Research on water immersion as an exercise-recovery method has employed immersion times ranging from 6 to 20 minutes.

To date, water immersion is thought to provide benefits similar to active recovery, such as increased blood flow and lactate removal, without the need to expend the extra energy associated with active recovery. Whether lactate is a component of fatigue is debatable, but the increase in blood flow throughout the body could reduce the delivery and removal transport time of substrates within the body, thereby aiding recovery.

**Recovery and Performance**

A small number of studies (see Table 1) have assessed water immersion’s ability to improve recovery between repeated bouts of exercise within a day or over a number of days. These studies have assessed the effect of water immersion on isometric strength, cycling, running, and jumping. Generally, these researchers have compared the effect of water immersion with passive recovery. Some of the studies, though, have included active recovery in an additional experimental group. Passive recovery refers to inactivity postexercise and the intrinsic return of the body to homeostasis and is used for a control group. The most basic form of such inactivity is sleep, but in these studies passive recovery refers to an
Table 1  Effect of Water Immersion on Performance*

<table>
<thead>
<tr>
<th>Author</th>
<th>Subjects</th>
<th>Study design</th>
<th>Exercise</th>
<th>Recovery modes</th>
<th>Outcome measures</th>
<th>Main findings</th>
</tr>
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<tbody>
<tr>
<td>Clarke28</td>
<td>30 men</td>
<td>X-over</td>
<td>2 × 2 min maximal hand grip</td>
<td>Passive, hot water, cold water (all for 10 min)</td>
<td>Hand MVIC</td>
<td>No significant performance change.</td>
</tr>
<tr>
<td>Coffey et al10</td>
<td>14 highly active men</td>
<td>X-over</td>
<td>2 sets of treadmill sprints (120% and 90% PRS)</td>
<td>Passive, active jogging, contrast therapy (both for 15 min)</td>
<td>Sprint times, critical power, RPErec, BLa</td>
<td>No differences in time or power between recovery modes (ES = 0 to 0.17). ↓ RPErec with contrast therapy. ↓ BLa recovery with passive recovery.</td>
</tr>
<tr>
<td>Burke et al39</td>
<td>21 women, 24 men</td>
<td>RCT</td>
<td>5 days of isometric strength training</td>
<td>Control, hot water, cold water (all for 10 min)</td>
<td>Hip-extension MVIC</td>
<td>All groups ↑ strength. Cold group had a MVIC ↑ that was twice that of the control (ES = 0.7) or hot group (ES = 0.7).</td>
</tr>
<tr>
<td>Lane and Wenger42</td>
<td>10 men</td>
<td>X-over</td>
<td>2 × intermittent cycle sprints</td>
<td>Passive recovery, active cycling, cold water, massage (all for 15 min)</td>
<td>Total work</td>
<td>↓ Total work after passive recovery. No change with active recovery (ES = −0.02) or immersion (ES = 0.02).</td>
</tr>
<tr>
<td>Sanders11</td>
<td>14 male state-level hockey players</td>
<td>X-over</td>
<td>2 × cycle Wingate test</td>
<td>Passive, active cycling contrast therapy (all for 12 min)</td>
<td>Total work, mean power, power decline, peak power, BLa, RPE</td>
<td>No performance difference between recovery modes. RPE lower at all times for immersion. Active and contrast-therapy BLa lower during recovery and posttest.</td>
</tr>
<tr>
<td>Vaile and Gill7</td>
<td>9 female and 4 male social athletes</td>
<td>X-over</td>
<td>DOMS-inducing leg press</td>
<td>Passive, contrast therapy (both for 15 min)</td>
<td>Squat MVIC, weighted jump squat, VAS score, thigh volume</td>
<td>Greater reduction in MVIC and jumping power with passive recovery (ES &gt; 0.33) than with contrast therapy. Immersion thigh volume increased less with contrast therapy.</td>
</tr>
<tr>
<td>Viitasalo et al17</td>
<td>6 female and 8 male national track-and-field athletes</td>
<td>X-over</td>
<td>5 strength-power sessions in 3 days</td>
<td>Passive, warm-water immersion (after evening trainings, 20 min)</td>
<td>Leg-extension MVIC, drop jumps, rebound jumps, VAS score</td>
<td>No significant MVIC benefit using water immersion (ES = −0.12 to 0.67). ↓ Power output and ↑ contact time in rebound jumps (ES = 0.37 to 0.68) when no water recovery was used.</td>
</tr>
</tbody>
</table>

*X-over indicates randomized crossover trial; MVIC, maximal voluntary isometric contraction; PRS, peak running speed; RPErec, rating of perceived recovery exertion; BLa, blood lactate; ES, Cohen effect size; ↓, significant decrease (P < .05); RCT, randomized controlled trial; ↑, significant increase (P < .05); RPE, rating of perceived exertion; DOMS, delayed-onset muscle soreness; and VAS, visual analogue scale.
athlete doing nothing out of the ordinary after a game or training; it is often seated inactivity\textsuperscript{7,11,15} or, if over a longer period of time (days), natural daily activity.\textsuperscript{7,16,17} Active recovery refers to light-intensity (<65\% $V_o_{\text{max}}$) exercise performed after competition or training. The duration of active recovery in practice varies, and in research it ranges from 7.5 to 20 minutes.\textsuperscript{10,18-21}

### Strength

Isometric testing using force transducers or dynamometers is a common\textsuperscript{22} method of assessing strength. Such testing involves a subject applying maximal force to an immovable object (maximal voluntary isometric contraction [MVIC]) using a small number of muscles.\textsuperscript{22} This form of testing bears little resemblance to sporting movements and has been observed to have low correlations with other performance measures such as sprints and jumps.\textsuperscript{23-27} The reader should be aware of this limitation when reading the following section.

Clarke\textsuperscript{28} conducted one of the earliest studies on the effect of water immersion on MVIC strength in 1963. In that study 30 male students maximally gripped a hand dynamometer for 2 minutes. For 10 minutes after the exercise the subjects recovered by immersing the hand in either hot (46°C) or cold (10°C) water or, for the control, used no immersion. Every 60 seconds during the recovery period subjects removed the hand from the water (if immersed) and were tested for maximal grip strength. Strength, which had initially decreased by 75\%, returned in a similar pattern (no significant differences) in each of the 3 recovery modes.

Although Clarke\textsuperscript{28} observed no improvements in strength recovery with warm- or cold-water immersion, there was a major methodological limitation in the study. Clarke exercised and immersed only the hand of each subject. Using such a small muscle group would minimize the build-up of metabolic waste and stress throughout the body. A compound exercise would have caused a greater level of systemic fatigue and might have increased the effectiveness of water immersion. In addition, immersing only the hand would have minimized 2 possible recovery mechanisms of water immersion. During submersion of a larger portion of a body there is an increase in the levels of extraintravascular fluid movement and an increase in cardiac output and blood flow.\textsuperscript{6} Large increases in these 2 factors might enhance the ability to transport and metabolize waste products.\textsuperscript{6} It might be expected, then, that if larger segments of body mass were submerged the effect of water immersion on recovery would be greater.

Other studies\textsuperscript{7,17,29} have employed immersion of larger body segments. Vitasalo et al\textsuperscript{17} conducted a randomized crossover study on 14 national track-and-field athletes. Over 3 days subjects had 5 training sessions consisting of strength training, plyometric drills, and sprinting drills. All sessions were standardized for volume and intensity. The subjects were randomly assigned to 2 groups, and after the evening training sessions 1 group was immersed, head out, in warm water (37°C) for 20 minutes, while the other group served as a control. Two weeks later subjects underwent the same training routine followed by the opposite recovery mode. During the exercise weeks the social and recreational activity of the subjects was made as similar as possible, and in between the experimental weeks, normal training was conducted. Leg-extension MVIC was assessed pretraining and on 3 occasions over 2 days after the training days. No significant differences between the
immersion recovery strategy and the nonimmersion treatment were reported in terms of isometric strength. Although nonsignificant, a moderate positive effect size (ES = 0.65) during the water-immersion week occurred in the first post-exercise-testing session. Other measures, however, taken 3 hours later on the same day and on the following day, showed trivial detrimental effects (ES = −0.12 and −0.08).

Viitasalo et al.\textsuperscript{17} used a subject group of elite athletes who trained in their normal environment with event-related drills and exercises. Large standard deviations (23% to 25% of the mean) were reported in the MVIC measurements, which might have produced the nonsignificant results and might account for the varied effect sizes. In addition, the testing protocol consisted of MVIC of the leg extensors using a dynamometer, rather than a compound movement involving the hamstrings, quadriceps, and gluteal muscle groups. This isolation of the leg extensors might reduce the study’s ability to detect fatigue if the fatigued state of each muscle group varies depending on the individual athletes and the event-related training drills that they performed.

Burke et al.\textsuperscript{29} conducted a study similar to that of Viitasalo et al.,\textsuperscript{17} in respect to multiple exercise sessions and water immersions over a number of days. Forty-five male and female subjects were randomly allocated to a control, hot-immersion, or cold-immersion group. Over 5 days subjects performed four 8-second repetitions of isometric contractions of the hip extensors at 60%, 70%, 80%, and 100% MVIC. For 10 minutes after the exercise subjects either were immersed in 8°C or 43°C water up to the gluteal fold or rested. All groups significantly increased force production from the first day to the fifth day. Increased force production (58%) by the cold-immersion group was more than twice (\(P < .05\)) the increase that occurred in the hot-immersion (26%) and control groups (27%). Strength gains could be related to the experimental design of the study, however, rather than the recovery benefits that might have resulted from immersion in cold water. Rather than have an absolute training load based on initial strength, intensity of muscle effort was based on the force produced during the 100% MVIC of the previous day’s training. Apart from the initial strength assessment, the daily MVIC produced by the cold group was higher than that of the hot or control group. This meant that although initially the lowest in strength (288 ± 92 N compared with 304 ± 135 N, control, and 314 ± 135 N, hot), the cold group trained with a higher relative workload throughout the study than the hot or cold group.

A point to consider with the study of Burke et al.\textsuperscript{29} was that they investigated the daily training effects of immersion rather than within-day immersion recovery effects. Cold-water immersion has been observed to decrease muscle-contraction velocity and, hence, power as a result of reduced neural activation\textsuperscript{30-33} immediately postimmersion. The postimmersion time course of this effect has not been established. Some studies have observed that the performance of short-duration, high-intensity exercise might be hindered by cold application in both normal and hot environments.\textsuperscript{34,35} In hot environments, however, cooling the body might be beneficial to endurance performance.\textsuperscript{36-38}

Another study that induced muscle fatigue in subjects was that of Vaile and Gill.\textsuperscript{7} Their crossover study attempted to induce muscle damage in the legs of subjects with supramaximal eccentric leg presses, then observe the effect that passive recovery or contrast therapy had on the recovery of strength. Recovery was performed immediately postexercise for 15 minutes using either alternations of
1-minute cold-water and 2-minute hot-water immersion of the legs (up to the gluteal fold) or seated rest. Strength was assessed using a Smith-squat MVIC immediately postrecovery and then every 24 hours over a 72-hour period. The eccentric exercise induced both pain (delayed-onset muscle soreness) and edema in the legs for 72 hours postexercise. A significant decrease (15.0% ± 11.9%) in peak isometric force was observed immediately after passive recovery. This decrease was 22.5% ± 12.3% at 48 hours, returning at 72 hours to baseline. Peak isometric strength after water immersion was never significantly different from baseline levels. The effect size of the difference in strength recovery in the water-immersion group compared with the passive group was moderate (ES = 0.76 to 0.83) over 48 hours and small (ES = 0.33) at 72 hours postexercise. Unlike Viitasalo et al., Vaile and Gill used a compound isometric assessment (isometric squat) to determine strength, providing a more valid measure of leg fatigue. Rather than using pure immersion, however, Vaile and Gill’s intervention consisted of contrast therapy. The effect that alternating temperature alone might have on strength recovery is not known. The exposure to $5 \times 60$ seconds of cold (8°C to 10°C) might have reduced the edema associated with delayed-onset muscle soreness and increased strength recovery, although such an effect of contrast therapy is unlikely. More research separating temperature variation from water immersion is required to determine which, if either, variable has some effect on postexercise strength recovery.

Vaile and Gill, Viitasalo et al., Burke et al., and Clarke did not use active recovery in their water-immersion studies for effect comparisons. It is possible that water immersion improves the recovery of maximal strength over a longer time period (days) if muscle damage has been induced. A paucity of research in this area, however, provides little evidence to determine the validity or worth of water immersion for postexercise strength recovery.

**Cycling**

Cycling offers one of the easiest methods to assess power, with the Wingate cycle-ergometer test being used a great deal in research. Cycling consists of a concentric-only application of force, however, whereas many sports consist of concentric–eccentric actions. One should be cognizant of this limitation when applying the findings of cycling research to other activities.

Two studies were found that examined the effect of both water immersion and active recovery between bouts of cycling. Sanders examined the performance recovery effect of active recovery, passive recovery, and water immersion on a repeated Wingate cycle test. After performing a 30-second bout of maximal cycling the 14 subjects recovered for 12 minutes by sitting on the cycle, performing low-intensity cycling, or contrast bathing ($3 \times 3.5$ minutes hot, 30 seconds cold) to the level of the sternum. Sanders observed no significant difference in power or work between the recovery modes, although the performance decline of passive recovery (1.8%) was greater than with active recovery (0.3%) and water immersion (0.5%). Sanders’ study, as with other immersion studies, used contrast therapy rather than immersion in which the water temperature is neutral in relation to body temperature. Short-duration alternating temperatures do not appear to cause large physiological changes intramuscularly and would therefore be unlikely to provide any performance benefits.
One other crossover study, by Lane and Wenger, has compared active recovery, passive recovery, and water immersion as cycling recovery strategies. A strength of the study was that it incorporated intermittent exercise, similar to the intermittent nature of team sports. The exercise consisted of an 18-minute cycling protocol of 22 intermittent maximal-effort sprints of 5 to 15 seconds duration with a work-to-rest ratio of 1:5. Recovery postexercise consisted of 15 minutes of passive sitting, cycling at 30% VO₂max, or immersion of the legs in cold water (15°C). Twenty-four hours later the subjects repeated the intermittent cycle protocol.

Change in performance was taken as the difference in work between the cycling sessions relative to the average work performed in the 5-second bouts. After 24 hours, work decreased by 78% ± 17% with passive recovery and 13% ± 24% with active recovery and increased with immersion by 11% ± 19%. The beneficial effect sizes were large compared with passive recovery when active recovery (ES = 1.20) and water immersion (ES = 1.65) were used. Why Lane and Wenger calculated change in performance using this method is unclear. Comparison of the total work performed over each session and each recovery mode produced effects that were much smaller. When recovery was passive there was a significant decrement (1.9% ± 4.6%, \( P < .05 \)) in total work in the second cycling bout, with no significant decrement in total work when active recovery or water immersion was the recovery method. Although significantly different from passive recovery, the beneficial effect of active recovery or water immersion on total work was trivial (ES = 0.11 and 0.16, respectively). Small beneficial effect sizes could be a result of the length of time (24 hours) between the exercise sessions. A within-day performance measure might have provided a better understanding of possible effects of the different recovery modes.

Although water immersion was not detrimental to cycle performance, similar to active recovery, the possible benefits observed were trivial. Based on the studies, there is not enough evidence to support the use of water immersion as a recovery between repeated bouts of cycling when considering the practicalities, time, and cost. Only 2 studies have been conducted, and neither replicated conditions that would be applicable to normal cycling events or training.

**Running**

Most sports consist of muscles acting in eccentric–concentric cycles of movement. During eccentric loading, higher forces can act on a muscle than during concentric loading, and greater muscle damage can occur. If mechanical damage to the muscle contributes to fatigue, actions that replicate eccentric–concentric muscle actions such as running or jumping might induce greater fatigue.

Coffey et al. observed no benefit with active recovery or water immersion compared with passive recovery on running performance. Fourteen highly trained athletes conducted 2 running sessions on a treadmill. Each running session consisted of a 120% maximal aerobic velocity run to failure, 10 minutes rest, and 90% maximal aerobic velocity run to failure. After these runs, for 15 minutes subjects rested passively, jogged at 40% maximal aerobic velocity, or performed contrast therapy to the level of the ilium. Four hours later the 2 runs were repeated. Although lower on the second bouts of running, no significant differences in run times or critical powers occurred between the recovery modes (ES = 0 to 0.17). Coffey et
al\textsuperscript{10} suggested that the second bout of exercise performed 4 hours postrecovery was a limitation because of perceived fatigue, blood pH, and lactate returning to baseline levels over this time. Such duration before repeating short exercise bouts might have reduced any effect that the different recovery modes had on performance, but this could be a practical time frame between exercise bouts for athletes in competition or training. Time to exhaustion after active recovery or contrast therapy was 8.4 to 17.9 seconds longer than after passive recovery, but these times were not significantly different from each other and amounted to trivial beneficial effect sizes of 0.08 and 0.16, respectively. Again, contrast therapy rather than immersion at a constant temperature was used, and temperature variation could have influenced any benefit.

Two other studies have compared the effect of water immersion (contrast therapy) with active and passive recovery on repeated sprinting performance.\textsuperscript{8,9} The reports in the literature on these studies were abstracts from conference presentations that did not provide enough information for a critical analysis. If the data are used as anecdotal evidence, these 2 studies observed no significant benefit to sprints repeated 1 or 2 hours after water immersion. Overall, water immersion would not appear to provide any benefit to recovery from short-duration maximal running compared with passive or active recovery.

Jumping

Fatigue from eccentric loading exercises such as plyometrics and eccentric presses appears to cause a reduction in jumping power,\textsuperscript{7,17,44} which might be attributed to muscle damage.\textsuperscript{7,44} Two articles\textsuperscript{7,17} that have been previously discussed have also assessed the effect of water immersion postexercise with regard to jumping ability.

Viitasalo et al,\textsuperscript{17} who conducted a study on 14 national track-and-field athletes over 5 days, assessed water immersion’s effects on changes in drop-jump and rebound-jumping kinematics and kinetics. Subjects performed 5 strenuous sessions of strength, plyometric, and sprint training over the course of 3 days. During the evening after training, subjects were either immersed in warm water or not immersed. Drop jumps and rebound jumping performance were measured preexercise and on 3 occasions postintervention (the following morning and afternoon and the next morning thereafter). A significant decrease (8% ± 8%, \(P < .001\)) in jumping power and an increase (6% ± 8%, \(P < .001\)) in ground-contact time were recorded during the week with nonimmersion compared with the immersion week. The effect size of the difference was small to moderate (ES = 0.37 to 0.68).

No other jump data were found to be significantly different by Viitasalo et al.\textsuperscript{17} If pre–post effect sizes are compared for the morning after the evening training, however, small positive effects are also apparent with immersion recovery for drop-jump height (ES = 0.30), drop-jump contact time (ES = 0.31), and rebound jump height (ES = 0.44). Average effects of the 3 postintervention measures resulted in small to moderate benefits for all performance measures except rebound jump height (ES = −0.05).

Vaile and Gill\textsuperscript{7} investigated whether there was a relation between muscle damage, edema, and muscle function and whether water immersion (contrast therapy) influenced these variables. They induced damage in leg muscles and
tracked weighted squat-jump performance over the next 3 days. After the induction of muscle damage subjects rested passively or immersed themselves in water for 15 minutes. Each day, squat jumps were performed on a Smith machine with a weight consisting of 30% of each subject’s MVIC squat force. The squat jumps were initiated from a knee angle of 90° with a 2-second pause, so the influence of the stretch-shortening cycle would have been minimized. Over 72 hours the return in squat-jump peak power to baseline occurred more quickly with water immersion than with passive recovery (24 and 72 hours, respectively). This significantly quicker recovery of peak power had a moderate to large effect size (ES = 0.67 to 1.46).

Accompanying the changes in peak power was a lesser increase and faster reduction in thigh circumference (reduced edema). Whether this reduction in fluid build-up in the thighs was a result of the cold application (alternated with hot temperature) or of the hydrostatic pressure of the water is again unknown. The trend of performance recovery and edema that Vaile and Gill observed in the legs of their subjects was similar to those of blood plasma restoration observed by Thiriet et al. Perhaps performance recovery is linked to the return of fluid from the muscles to the blood and requires further investigation.

From the 2 studies that measured jump performance and water immersion, there appears to be some benefit to performance when using water immersion. Whether water immersion has any influence in repeated jump performance within a day has not been studied.

**Practical Application and Conclusions**

In summary, 10- to 20-minute water immersion is unlikely to be detrimental to athletic recovery. In some studies the use of water immersion postexercise maintained strength and jump ability but not cycling or running performance. The magnitude of these observed performance changes might be a result of the exercise protocol rather than the performance measure in the studies. Athletes who underwent intense exercise sessions that caused prolonged muscle fatigue (muscle damage) benefited from water immersion. In addition, benefits were observed with athletes who, over a number of days, performed multiple bouts of strength and plyometric exercise and water-recovery sessions. The beneficial effects of water immersion from a single-repeat, short-duration exercise were found to be trivial to small, or about the same as the mean variance. Reduced muscle edema caused by hydrostatic pressure during water immersion might be the mechanism that could provide the observed benefit to performance recovery.

Whether water immersion provides greater recovery benefits than does active recovery is unclear. The 2 studies that observed greater than trivial effects were dissimilar in all aspects, including the water-immersion protocols. Considering the trivial benefits and the time, cost, and impracticality of conducting water immersion between repeated short-duration exercise bouts, we would suggest that this form of recovery is only useful if the exercise is intense enough to cause muscle damage. The effect that water temperature has on recovery is unclear, with beneficial effects observed for contrast therapy, warm/hot immersion, and cold immersion. Therefore the best practice might be to use water immersion and associated water temperature according to the personal preference of the athlete. One should be aware that there are many limitations in the research on which these findings are based, and a great
deal of research is needed before definitive conclusions can be made. Performance parameters, exercise mode and intensity, water temperature, immersion duration, immersion depth, recovery timelines, and longitudinal effects of water immersion on performance are a few of the areas that require research.

References


