DEEP-WATER RUNNING: A PRACTICAL REVIEW OF THE LITERATURE

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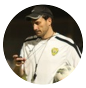

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Deep-water running: a practical review of the literature

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Abstract

Deep-water running (DWR) is performed in the deep end of a swimming pool, normally with the aid of a flotation vest or a special suit with hydro buoyancy system. The method is used for preventing injuries, recovery from strenuous exercise or competition, and as a form of complementary training for cardiovascular fitness. Responses to training programmes have confirmed the efficacy of deep-water running but proper DWR technique should mimic the patterns of land-based running. The concept of training specificity should be further considered when prescribing DWR and using it as an enhancement tool or substitute for dry land running. Although cardiorespiratory responses during DWR are well studied, further investigations should concentrate on identifying how active specific muscles during DWR.

The method of running in deep water

The method of DWR is used for different purposes as preventing injury and promoting recovery from strenuous exercise or as a form of complementary training for cardiovascular fitness. A reduction in spinal loading constitutes a role for deep-water running in the prevention of injury, while an alleviation of muscle soreness confirms its value in recovery training (Reilly & Ekblom, 2005). Endurance running places repetitive stress on the lower limbs and lower back. Compressive loading is inevitable during running as the feet impact with the ground 600-1200 times per km (Valliant 1990), with each foot strike inducing ground reaction forces equivalent to 2-4 times the body weight (Cavanagh, 1980). When the compressive load exceeds the osmotic pressure of the discal tissues, fluid is expelled from the intevertebral discs: The resultant loss in disc height is reflected in a loss of height which has been referred to as spinal shrinkage (Reilly, 1984). One study supports the use of DWR for reducing the compressive load on the spine in both injured and uninjured runners (Dowzer, Reilly & Cable, 1998). The final conclusion was that running in deep water produced significantly less spinal shrinkage than either the treadmill or shallow water conditions, no difference being evident between the treadmill and shallow water running.

DWR is also used as an injury-rehabilitation technique (i.e limb stress fracture) (Liem, Truswell & Harrast, 2013) and as conventional physical training in the days after competition (Reilly & Ekblom, 2005). In a study of 30 previously untrained individuals, DWR proved to be superior to other putative methods of reducing muscle soreness and restoring muscle strength following ''stretch – shortening regimen" (SSR) (Reilly, Cable, & Dowzer, 2002). This kind of exercise employed to induce soreness consisted of drop jumps from a platform 50 cm in height once every 7 s until voluntary exhaustion. Exercise on the three subsequent days consisted of running for 30 min at 70 –80% of heart rate reserve. The methods of recovery examined were: (1) rest on all days; (2) rest on day 1, DWR on remaining days; (3) rest on day 1, treadmill running on later days; (4) treadmill run on all days; and (5) deep-water running on all days. The most effective recovery was when DWR was incorporated in the training programme for all 3 days following the SSR. DWR failed to prevent delayed-onset muscle soreness but appeared to speed up the process of recovery for muscle strength (determined using isokinetic dynamometry) and perceived soreness. CK concentrations peaked 24 h earlier and at a lower value in the group employing deep-water running compared with the other groups. Soreness was eliminated while participants were running in deep water but returned post exercise, having allowed exercise to proceed pain free. The

DWR strategy also enabled participants to maintain range of motion at the hip joint while they were experiencing soreness. These factors could be linked with the smaller decline in leg strength that occurred when DWR was employed.

The physiology of DWR

DWR maximal heart rate and oxygen consumption values have been consistently shown to be lower than those found during running on dry land (Dowzer, Reilly, Cable & Nevill, 1999; Frangolias et.al. 1995; Mercer & Jensen 1997, 1998; Nakanishi, Kimura & Yokoo, 1999; Reilly, Dowzer & Cable, 2003; Svedenhag & Seger, 1992;). However, recent evidence reveals that DWR is a comparable form of submaximal intensity exercise as treadmill regimenes in well-trained athletes (DeMaere & Ruby, 1997). Furthermore, when the subjects were elderly women, these responses were higher during submaximal deep-water running than during treadmill running (Broman et. al. 2006). Results showed an improvement of submaximal work capacity (a reduction of 3% in HR), maximal aerobic power (an increase of 10% in VO_2), and maximal ventilation (an increase of 14%) with the effects transferable to land based activities (Broman et. al. 2006). Therefore, sedentary individuals benefit more than athletes in improving maximal oxygen uptake (Reilly, Dowzer, Cable, 2003).

Responses to training programmes have confirmed the efficacy of deep-water running, although positive responses are most evident when measured in a water-based test. Aerobic performance is maintained with deep-water running for up to 6 weeks in trained endurance athletes (Reilly, Dowzer & Cable, 2003). Otherwise, there is some limited evidence of improvement in anaerobic measures and in upper body strength in individuals engaging in deep-water running (Reilly & Ekblom, 2005).

One relevant consideration:
It is important for the physician or sports medicine practitioner to focus on the underlying physics and biomechanics of running in water in order to better produce the desired physiological metabolic, and psychological outcomes (Killgore, 2012).

DWR Technique

The concept of training specificity should be further considered when prescribing DWR and using it as an enhancement tool or substitute for dry land running. (DeMaere & Ruby, 1997). Authors as Azevedo et. al. (2010) conclude that adaptation to deep water running reduces the difference in VO2max between the two modalities, possibly due to an increase in muscle recruitment. DWR technique, psychological comfort, perception of work, muscular recruitment patterns, and running kinematics are all affected by the physics (ie, temperature, buoyancy, hydrostatic pressure, specific gravity, and drag) of running in water (Killgore, 2012).

Proper DWR technique should mimic the patterns of land-based running. The stride should be very similar to that of sprinting in order to maximize the specificity of the movement to running on land (Killgore, 2012). An upright posture with the trunk perpendicular to the running surface is ideal running position, allowing mobility of the pelvis and lumbar spine (Killgore, 2012). Some studies (Kaneda et. al. 2009) revealed forward inclinations of the trunk were apparent for DWR with flotation vest: the pelvis was inclined forward in DWR. In conclusion, the higher-level activities during DWR are affected by greater hip joint motion and body inclinations with an unstable floating situation. DWR with the aid of extra buoyancy system (i.e suit with buoyancy pads in legs, arms and trunk, front and back) allows the head top to remain above the water and helps in maintenance of an upright position. The positioning and different thickness of the core and back pads helps to hold a person in the correct biomechanical body position. This is very important concept to maintain proper ventilation, as the chest is already under increased strain during DWR because of the hydrostatic pressure of the water on the thoracic cavity. This special device also adds resistance to arm and leg work without risking injury: The water resistance imposed on the body during aquatic locomotion is much greater than that on land, as water is about 800 times more dense than air (DiPampero, 1998). Furthermore, the water generates an additional resistance, with an increase in speed and surface area of the body (Shanebrook & Jaszczak, 1976).

Muscle activity during DWR

Although cardiorespiratory responses during DWR are well understood, there has been little research on identifying how active specific muscles are during DWR. This work is important to better understand the salient features of DWR that allow it to be a suitable alternative to running on dry land.

Masumoto et. al. (2009) evaluated 7 healthy subjects who performed DWR and treadmill running (TMR) at rate perceived exertion (RPE) values of 11 (fairly light), 13 (somewhat hard), and 15 (hard). Surface EMG was used to evaluate muscle activity of the rectus femoris (RF), biceps femoris (BF), tibialis anterior (TA), and gastrocnemius (GA) with average EMG calculated across a 30-s window. It was concluded that the muscle activity levels of the TA and GA were lower during DWR than during TMR when exercise intensity was matched on RPE. In contrast, the muscle activity levels of the BF and RF were either not different or tended to be lower during DWR than TMR at matched RPE. Most importantly, it seems that higher levels of RPE are needed during DWR to achieve muscle activity levels and patterns that are more similar to TMR lower intensity exercise. In another study from Masumoto et. al. (2013), the authors compared different styles of DWR (high-knee style, HK and cross-country style, CC) with treadmill running on dry land, as well as to investigate effect of stride frequency (SF) on muscle activity. From all tested muscles during both styles, muscle activity levels increased with increasing SF. These observations indicated that muscle activity is influenced not only by running in the water but also by the two styles of DWR tested.

Conclusions

DWR is used by a variety of populations either as a mode of exercise during rehabilitation or as a supplement to an exercise program because it is thought that this exercise is less likely to cause injury than dry land running. DWR is also promoted as light recovery sessions immediately after or the day following competitive games. DWR with the aid of extra buoyancy system allows a correct biomechanical body position. Although cardiorespiratory responses during DWR are well studied, further investigations should concentrate on identifying how active specific muscles during DWR.

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