INFLUENCE OF DEEP WATER RUN TRAINING SUPPLEMENT ON THE MAINTENANCE OF AEROBIC PERFORMANCE AND KINEMATICS OF MIDDLE-DISTANCE RUNNERS

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The purpose of this study was to examine whether trained competitive runners could maintain on-land running performance and kinematics, using 8 wk of deep water run supplement training (30%) instead of just on-land training. Eight trained male runners (VO_{2MAX}: 53,3 ± 4.1 ml. Kg^{-1}. min^{-1}) were assigned to one of the two groups, on-land run just (R) or water run supplement (WR). Following 8 wk of workouts, no significant intragroup or intergroup differences were observed for treadmill VO_{2MAX}, running economy, horizontal velocity, stride length, stride rate, time of support, time of flight and segmental body positions. It was concluded that deep water running may serve as an effective training supplement to land-based running for the maintenance of aerobic performance and running kinematics for up 8 wk in trained middle-distance runners.

KEY WORDS: kinematics, aerobic performance, deep water running training, middle-distance running.

INTRODUCTION: The human running gait is a component of most forms of physical activity and, because of its relative simplicity of execution, it is a major mode of activity for fitness development as well as a training mode for most sports. Although the physiological benefits of running are well documented and noteworthy, its overuse has contributed to a wide range of foot and leg injuries (Glass *et al.*, 1995). Deep water running (DWR) is a popular form of cardiovascular conditioning for injuried athletes as well as for other athletes who desire a low impact aerobic workout. DWR, or aqua running, consists of simulated running in the deep end of a pool aided by a flotation device (vest or belt) that maintains the head above water (Wilder & Brennan, 1993). Researchers have found significant differences in the physiological responses to deep water running and land based running. However, the effect of chronic DWR training supplement on the maintenance of cardiorespiratory conditioning has not been investigated extensively, particularly among trained individuals (Wilber *et al.*, 1996, Eyestone *et al.*, 1993). Therefore, any authors have stated that movement pattern of DWR is different land-based running (Tartaruga *et al.*, 2001, Nilsson, Tveit and Thorstensson, 2001). Thus, the purpose of the present investigation was to examine the biomechanical and physiological effects of the inclusion of DWR as part of a training program instead of just on-land training to trained middle-distance runners.

METHODS: The subjects for this study were 8 aerobically trained Brazilian middle-distance runners of national level (2 female and 6 male) who ranged in age from 15 to 28 years. The investigation was conducted from late October to early January to facilitate compliance and avoid major competitions. Subjects were fully informed of the risks and stresses associated with the project before giving their written consent. Subjects were 21 ± 8.1 years old, weighed 66.5 ± 12.5 kg, were 174 ± 11.5 cm tall, and had a VO_{2max} of 53.3 ± 4.1 ml.kg^{-1}.min^{-1}. Following preliminary screening, subjects were assigned to one of the two training groups matched by VO_{2max}, either just on-land running (R) or deep water running training supplement (WR). The WR were 30% of the on-land training volume transferred to water (deep water running). Both groups were required to follow the same workout schedule, which consisted of alternate high-intensity interval sessions (30 min at 90-100% VO_{2max}) and moderate-intensity recovery sessions (60 min at 70-75% VO_{2max}) performed 5 d.wk^{-1} for 8 weeks. Subjects were evaluated at the beginning and at the end of the eight weak experimental period. As the training volume and duration were similar to that of the subjects' normal training, we did not attempt to precisely match the previous

R with WR training. Instead, we used a standard protocol recommended for deep water running to simulate a protocol typically used by a runner with an injury. The Brennan Scale (Wilder & Brennan, 1993), a 5-point perceived exertion scale, was used to set the workout intensity. The scale had verbal descriptors ranging from very light to very hard. Each level was also equated with on-land running intensities as follows: level 1 corresponds to a light jog or recovery run, level 2 corresponds to a long steady run, level 3 corresponds to a 50 to 10 km race, level 4 corresponds to a 400 to 800 m track interval, and level 5 corresponds to sprinting 100-200 m. Michaud *et al.* (1995), also used this scale to prescribe intensity for deep water running exercise in healthy sedentary individuals. Both pre- and post-training, the runners completed a maximal oxygen consumption (VO_{2max}) test on one day, and a running economy test on the treadmill and a 500m race on the track on another day. The pre-training tests were conducted at least 4 d apart from the subjects continuing to on-land running between the two test days. The post-training tests were conducted at least 2 d apart from the subjects continuing with R or WR training. The running kinematics were registered with a video camera at 50m and 450m of 500 m race. The 2-D filming was obtained with a camera (Punix F4, 120 Hz) that was placed on the runner saggital plane, 6.8 m far from the runner, respectively, linked to a video system (Peak Performance vs 5.3). Reflexive tape was used to obtain a better contrast of the hip, knee and ankle joint centers. The deep water running training was done in a swimming pool of 25x16 m, 2m depth, which the subjetcs used a float belt and the water temperature ranged between 28.5° C and 29.5° C.

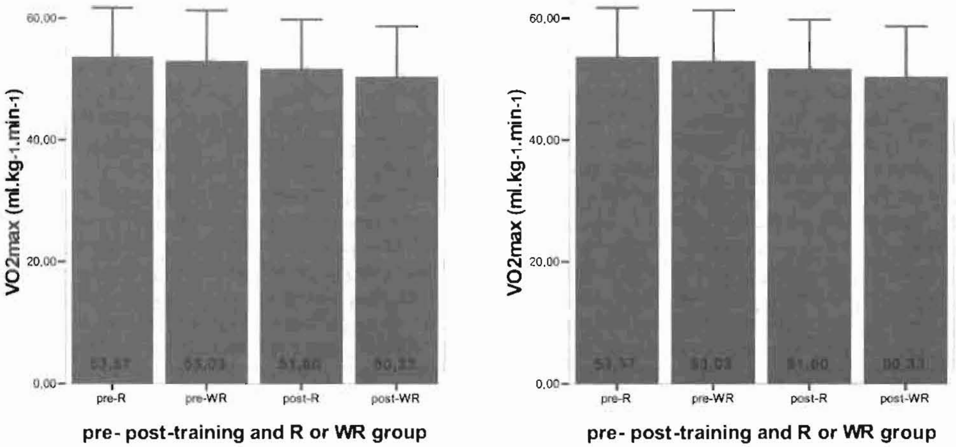

Figure 1. Means and standard-desviations of VO_{2max} and running economy at pre- and post-training.

Data processing: The video recordings were manually digitized using a Peak Performance Measurement System (Peak Performance Technologies, Denver, CO, USA). All the curves were filtered with a Butterworth filter and a cut-off of 11Hz. To determine the kinematic variables the mean horizontal velocity of anatomical hip point into one step cicle was considered. Paired *t*-tests were used to compare the pre- and post-training dependent variables (VO_{2max} during VO_2 tests; VO_2 during the running economy tests; the race time (RT), horizontal velocity (HV), stride length (SL), stride rate (SR), time of support (TS), time of flight (TF), knee angle at toe-off (KAT) and knee angle at touchdown (KAO) during the 500-m race). Therefore, independent -sample *t*-

tests were used to compare the R and WR group dependent variables. Thus, for all *t*-tests an alpha level of $P < 0.05$ was used.

RESULTS AND DISCUSSION: Preexperimental treadmill VO_{2max} (Figure 1) was 53.6 ± 3.2 and 53.0 ± 5.1 ml.kg^{-1}.min^{-1}. Following eight weak of workouts, no significant intra- or intergroup differences were observed for R (pre = 53.6 ± 3.2, post = 51.6 ± 3.3 ml.kg^{-1}.min^{-1}) and WR (pre = 53.0 ± 5.1, post = 50.3 ± 5.2 ml.kg^{-1}.min^{-1}). Similarly, running economy was unaltered in R (pre = 41.3 ± 6.8, post = 40.8 ± 5.3 ml.kg^{-1}.min^{-1} at 16 km/h) and WR (pre = 43.2 ± 5.2, post = 44.1 ± 5.5 ml.kg^{-1}.min^{-1} at 16 km/h). Eight weeks of WR apparently provided a sufficient training stimulus to maintain on-land running performance in a group of well-trained distance runners. This finding is in agreement with Wilber *et al.* (1996) and Bushman *et al.* (1997), who investigated trained runners and reported that treadmill VO_{2max} for water runners was not different to land-based runners after six and four weeks of workouts, respectively. Although the data of the present investigation showed an approximate 5% decline in VO_{2max} at post-training; however, these behavior was also found on R group (about 4% decline), moreover these nonsignificant changes probably reflect normal day-to-day variation in maximal aerobic capacity (Katch *et al.*, 1982).

Table 1. TR, HV, SL, SR, TS, TF, KAT and KAO (Mean and Standard deviation) at 50m and 450m of 500-m race. (n = 8, * p<0.05).

	R		**WR**	
	Pre- training	**Post-training**	**Pre-training**	**Post-training**
TR-500m (s)	84.1 ± 9.8	79.8 ± 8.0	78.1 ± 9.1	77.0 ± 7.4
HV-50m (m/s)	6.68 ± 1.05	6.82 ± 0.70	7.16 ± 1.06	7.25 ± 0.71
HV-450m(m/s)	5.64 ± 0.89	5.56 ± 0.84	6.10 ± 0.64	6.27 ± 0.25
SL-50m (m)	3.98 ± 0.37	3.88 ± 0.42	4.30 ± 0.52	4.41 ± 0.40
SL-450m (m)	3.75 ± 0.51	3.46 ± 0.54	3.97 ± 0.25	4.04 ± 0.33
SR-50m(st/mi)	101.1 ± 6.9	105.6 ± 3.4	102.5 ± 6.4	98.7 ± 2.2
SR-450m(st/mi)	97.9 ± 12.8	96.5 ± 5.3	93.4 ± 6.5	93.4 ± 4.3
TS-50m (s)	0.12 ± 0.05	0.10 ± 0.02	0.12 ± 0.05	0.17 ± 0.10
TS-450m (s)	0.17 ± 0.10	0.13 ± 0.03	0.20 ± 0.10	0.13 ± 0.02
TF-50m (s)	0.45 ± 0.04	0.46 ± 0.03	0.39 ± 0.06	0.50 ± 0.03
TF-450m (s)	0.49 ± 0.08	0.49 ± 0.08	0.45 ± 0.11	0.53 ± 0.05
KAT-50m (d)	154.4 ± 3.0	141.3 ± 6.3	154.7 ± 7.7	146.9 ± 14.2
KAT-450m (d)	153.8 ± 10.9	151.8 ± 10.1	159.6 ± 10.5	152.3 ± 11.8
KAO-50m (d)	154.7 ± 4.3	158.8 ± 3.1	153.4 ± 7.0	153.9 ± 4.0
KAO-450m (d)	150.4 ± 15.1	153.0 ± 5.0	152.1 ± 6.9	152.7 ± 4.3

Note: st/mi = stride per minute, d = degrees.

For cross training to be effective in maintaining VO_{2max}, it must employ a training pattern that is equivalent in intensity and duration to the original exercise mode. In addition, the cross-training exercise modality must replicate the range of motion and skeletal muscle recruitment pattern of the original exercise mode. In the present study, the WR was equivalent in intensity and duration to treadmill workouts, but it is known that deep water running appears to recruit lower extremity of different way. The eccentric action of hamstrings, vastus lateralis and rectus femoris, as well as their stretch-shortening cycle during the support phase in over-ground running, are absent in deep water running. Therefore, the angular kinematics of the leg is different substantially between the two modes of locomotion (Tartaruga *et al.*, 2001, Nilsson *et al.* 2001). Nevertheless, the 30% change of volume from on-land running to deep water running was not sufficient to decrease the TR at 500 m race and running kinematics during the test, that is, no significant differences were observed within or between groups ($P > 0.05$) for HV, SL, SR, TS, TF, KAT and KAO at 50m and 450m of 500 m race (table 1).

CONCLUSION: Our finding may have implications for current training programs used for middle-distance runners.There is emerging evidence that deep water running included in a training program can be used as substitutive exercise to on-land running up to 30% of training volume.

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