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Research article

EFFECT OF DRY-LAND DRILL ON THE PERFORMANCE OF FEMALE ATHLETES IN ARTISTIC SWIMMING

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Abstract. *It is a common practice among female athletes of artistic swimming to execute a dry-land drill of their routine just before its final execution in the water. The potential advantages of this established procedure have never been confirmed on an experimental basis. This study aimed at providing statistical evidence vindicating the dry-land drill. Forty seven Greek athletes of artistic swimming (seven of whom belong to the Greek National team) were given a routine containing standard figures, positions and movements. This routine was performed twice, with and without prior dry-land drill, executed in a random order with a lapse of one week between the two performances. The same three international judges were recruited to rate the performances in the standard three panels of execution, difficulty and artistic impression. The ratings of the performance including a dry-land drill were significantly better (paired t-test, $p<0.001$) than those without it. This improvement was consistent in all categories and levels of athletes. The enhancement in the performance brought about by the execution of a dry-land drill was more pronounced in younger athletes. The improvement in athletes' performance when they execute a dry-land drill may play an important role in the ranking of the athletes in national and international events. Dry-land drill should be recommended as a standard operating procedure in artistic swimming.*

Key words: *Artistic swimming, Dry-land drill, Performance*

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INTRODUCTION

Artistic swimming (AS) of female athletes under the auspices of The Federation Internationale de Natation (FINA) has rightly gained its entrance as an event of the Olympic Games since 1984 in Los Angeles with the solo and duet events. In 2000 at the Sydney Olympic Games, the team event replaced the solo event.

There is a specific peculiarity in AS: Regardless of the competition level and whether it is a solo, a duet or a team routine, athletes execute a dry-land drill (DLD) of their routine just before its final execution in the water. In the dry-land drill athletes simulate to the music all in-water movements on land (Mountjoy, 1999). According to the researcher, AS is a complex, highly developed, physically intensive sport that demands strength, power, endurance, flexibility, artistic expression, and performance skill. In order to synchronize to each other and the music in the routine events, AS athletes execute a dry-land drill accompanied by their music reverberating all the movements' details.

In previous research Orlick and Partington (1986) recorded the story of elite athletes of Canada participating in different sports (swimming, artistic swimming, diving, rowing, canoe, rhythmic gymnastics, shooting, alpine skiing, wrestling, basketball and figure skating), who achieved great success in world class level with the combination of mental training and tough physical training. Specifically, in AS, Kryczka and Hambrook participated in the duet event of Olympic Games of 1984 and won the silver medal. Kryczka revealed that their preparation included practice, mental training of figures and routine and dry-land drill accompanied by their music half an hour before its final execution in the water. Supplementing mental training, dry-land drill involves the actual execution of the routine outside the water.

There is enough evidence that combination of mental and physical training improves kinetic performance and yields better results (Feltz & Landers, 1983; Grouios, 1992; Hinshaw, 1991). Cox (2012) noted that athletes, in order to achieve their best performance, have to train themselves both mentally and physically. With regards to AS, Chairopoulou (2010) added that the combination of the two above training modalities outside the water combined with in-water training provide the quickest and best results. According to Martens (1987), athletes may use mental training to train quickly without physical tiredness or exposure to the risk of injuries.

The majority of research on AS revolves around injuries and common medical problems (Mountjoy, 1999; 2008; 2009), physiological requirements of the sport (Bjurström & Schoene, 1987; Naranjo, Centeno, Carranza, & Cayetano, 2006; Yamamura, Matsui, & Kitagawa, 2000; Yamamura et al., 1998; Yamamura et al., 1999), anthropometrics and its influence on athletic performance (Sajber et al., 2013), nutrition practices (Bronwen, 2011), psychological aspects and athlete satisfaction (Ntomali, Psychountaki, Kyprianou, & Chairopoulou, 2017). Additionally, synchronized swimmers have been the subject of studies based on their age or competitive category (Ebine, Feng, Homma, Saitoh, & Jones, 2000; Peric, Cavar, Zenic, & Sekulic, 2014; Sajber, Peric, Spasic, Zenic, & Sekulic, 2013) and the athletes' competition level (Ebine, Feng, Homma, Saitoh, & Jones, 2000; Homma & Homma, 2006; Rodríguez-Zamora et al., 2014; Rostkowska, Habiera, & Antosiak-Cyrak, 2005).

As mentioned before whether it is a solo, a duet or a team routine, an important component of AS training is the practice of dry-land drill before the final execution in the water. Nevertheless, up to date, there has been no report as to whether this practice is effective or not.

The purpose of the present study is, through a controlled experimental procedure, to provide statistical evidence vindicating the dry-land drill on athletes' performance when they execute the routine in the water.

METHODS

Participants

The study included 47 female athletes of AS, aged at least 13 years. Prerequisites were that: a) they were active athletes, b) they had at least two years of athletic experience, and c) they had qualified for the Greek National Championship in their category. The classification of the athletes was done on the basis of:

a) their competition category according to the rules of The Federation Internationale de Natation (FINA, 2017) into: (i) Seniors; aged at least 19 years, (ii) Juniors; aged 16-18 years, and (iii) Comen; aged 13-15 years.

b) the athletes' level into: (i) International level – members of the national team and (ii) National level – with participation only in national events.

The initial approval for the participation of the athletes was given by the head coach and the team manager of each club and by parents in cases when the athletes were under 18 years old. There followed a 15-minute briefing about the purpose of the study and what was required on the part of the athletes. After the athletes were assured that their participation was voluntary and confidential, they filled in a form concerning their athletic profile. The Ethics Committee of the university (National and Kapodistrian University of Athens, School of Physical Education & Sport Sciences), where the study was conducted, approved this study (protocol No: 1028/8/11/2017).

Measurements/Procedure

All participating athletes were given the same choreography comprising the same number of necessary elements one week prior to the start of the experiment. The routine that athletes executed was based on new FINA Artistic Swimming Rules 2017-2021 and included basic positions, transitions, figures (Rio, Porpoise Continuous Spin 720^{o}, Aurora Twirl, Whirlwind), twists, arm movements, boosts, eggbeater, strokes and propulsion, drills required for the composition of the choreography.

The 47 athletes were randomly assigned to one of two groups (A and B). Group A performed warm-up in swimming that included swimming styles, basic positions and movements of AS. Subsequently, the athletes performed the routine in the pool that included compulsory drills of AS (2017-2021 FINA Artistic Swimming Manual for Judges, Coaches & Referees) (FINA, 2017) and were rated by three official judges of AS (Condition I: warm-up swimming and AS routine).

Group B performed warm-up in swimming that included swimming styles, basic positions and movements of AS. After this the athletes performed a dry-land drill (DLD), i.e. they performed the AS routine outside the water accompanied by music. Subsequently, the athletes performed the routine in the pool and were rated by the same three official judges of AS (Condition II: warm-up swimming, DLD and AS routine).

The AS routine was the same for all athletes. One week later, Group A performed the routine under Condition II and Group B performed the routine under Condition I.

In both conditions the rating of the athletes' performance was given by the same three official judges who are qualified to judge in National and International AS events. The competitor can obtain points from 0 – 10 using 1/10th points, as shown in Table 1, according to FINA Artistic Swimming Rules, 2017-2021.

Table 1 Grading according to the points gained in AS competitions.

Grading	Points	Grading	Points
Perfect	10	Satisfactory	5.9 – 5.0
Near perfect	9.9 – 9.5	Deficient	4.9 – 4.0
Excellent	9.4 – 9.0	Weak	3.9 – 3.0
Very good	8.9 – 8.0	Very weak	2.9 – 2.0
Good	7.9 – 7.0	Hardly recognizable	1.9 – 1.0
Competent	6.9 – 6.0	Completely failed	0

Note: AS - Artistic Swimming

Competitors were rated, according to the rules, in three panels: Execution, Difficulty and Artistic Impression. The average of the three panels gives the points for the final rating for each judge and the average of the three judges yields the final rating of the athlete's performance.

Statistical analysis

The primary outcome was the athletes' performance under two conditions (Condition I: without DLD, Condition II: with DLD). This variable will be presented as mean±SD and will be compared between the two conditions with the paired t-test, both for the total sample and for the category and level subgroups. A general linear model (GLM) was also applied including within subjects (two conditions) and between subjects (category) effects, as well as the order of execution as a random effect in order to account for any bias introduced by the effect of learning. Inter and intra-rater reliability was assessed with the intraclass correlation coefficient (ICC) also reporting its 95% confidence intervals (CI).

All analyses were performed with the IBM SPSS Statistics for Windows, version 26 (IBM Corporation, 2017) and corroborated with the R statistical package (R Core Team. R, 2016). The level of significance was set at 0.05.

Sample size calculation – Power analysis

The sample size calculation was performed on the basis of the primary hypothesis of the study that examines the difference in the performance of the athletes when the routine program is executed with and without dry-land drill (DLD). Consequently, the primary statistical test will be the paired t-test (with and without DLD) of the continuous variable of the performance as graded by three international AS judges. The expected difference of the means in the two conditions is 0.1 with a standard deviation of 0.2. If the power of the study is set to 0.9 (90%), then in order to reject the null hypothesis of no difference between the two means at the level of significance of α=0.05, a sample size of at least 44 athletes is required. The power analysis was performed with the PS – Power and Sample Size Calculations (Dupont & Plummer, 1997) software and confirmed with the G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) program.

RESULTS

Descriptive statistics (mean ± SD) regarding the profile of participants (age, athletic experience, number of competitions) for each of the three competition categories (Seniors; Juniors; Comen) are presented in Table 2.

Table 2 Descriptive statistics (mean ± SD) for each of the three categories and for the total sample.

Parameter	Seniors	Juniors	Comen	Total
Number of athletes	9	7	31	47
Age (years)	21.7 ± 2.1	16.6 ± 0.5	13.9 ± 0.8	15.8 ± 3.3
Athletic experience (years)	11.8 ± 3.1	5.9 ± 2.3	5.3 ± 1.9	6.6 ± 3.3
Number of competitions	46.2 ± 23.4	9.6 ± 9.8	6.8 ± 3.5	14.7 ± 18.9

As Table 3 shows, both the inter and intra-rater reliability coefficients are very high. In conjunction with the fact that the ratings of the judges for the three panels in both conditions do not vary significantly (paired t-tests, p=NS), it allows to express the overall performance of each athlete in each condition by a single number that averages over the ratings of the three judges and the three panels separately for each condition.

Table 3 Inter-rater intraclass correlation coefficients (ICC) with their 95% CI for the ratings of the three judges for each panel and for the total under each condition. In italics is the intra-rater ICC between the three panels for each judge.

	Condition I (without DLD)		Condition II (with DLD)	
Panel	ICC	95% CI	ICC	95%
Execution	0.990	0.984-0.994	0.992	0.988-0.995
Difficulty	0.992	0.987=0.995	0.990	0.984-0.994
Artistic impression	0.990	0.984-0.994	0.989	0.981-0.993
Total	0.998	0.996-0.999	0.997	0.996-0.998
Intra-rater ICC				
Judge 1	*0.995*	*0.991-0.997*	*0.996*	*0.993-0.998*
Judge 2	*0.994*	*0.990-0.996*	*0.992*	*0.987-0.995*
Judge 3	*0.995*	*0.992-0.997*	*0.994*	*0.990-0.996*

Twenty-two athletes performed first the routine under condition I and the rest twenty-five athletes performed first the routine under condition II. The correlation coefficient between the rating of the athletes' performance in condition I and condition II is almost perfect (r=0.990, p<0.01), which means that the athletes managed to perform the routine in a consistent manner. However, the mean rating in condition II (with DLD) is significantly greater than in condition I (without DLD) (6.5±1.3 vs. 6.2±1.3, paired t-test, t_{46}=10.3, p<0.01). This means than in condition II the athletes performed consistently better than in condition I.

The GLM procedure showed that the order of execution of the conditions did not have a significant effect on the ratings of the athletes' performance ($F_{1,41}$=0.98, p=0.329). In contrast, the within subjects factor of the conditions had a significant effect on the ratings

($F_{1,41}$=35.4, p<0.001), as also did the between subjects factor of category ($F_{2,41}$=15.9, p<0.001). Post-hoc comparisons (Table 4) showed that the difference between the two conditions is statistically significant at the 0.05 level for senior athletes and at the 0.001 level for the junior and comen categories. Also, in both conditions the senior category scored significantly more than each of the other two categories (p<0.001).

Table 4 Mean values (±SD) of the ratings of the performance of the athletes in the routine for each category and each condition. Comparisons between conditions for each category and between categories for each condition. Asterisks denote that the senior category had significantly greater values than each of the other two categories.

Category	Condition I (without DLD)	Condition II (with DLD)	Difference	p-value
Seniors	7.9±0.9*	8.1±0.7*	0.2	0.021
Juniors	5.5±0.7	5.8±0.7	0.3	<0.001
Comen	5.9±1.0	6.2±1.1	0.3	<0.001
p(ANOVA)	<0.01	<0.01		

Note: DLD - Dry-land drill

Likewise, as Figure 1 shows, the performance of international level athletes is not comparable to the performance of national level athletes in both conditions. However, both groups evidenced a significant improvement when performing after dry-land drill. The improvement of athletes of national level was significantly greater than that of athletes of international level.

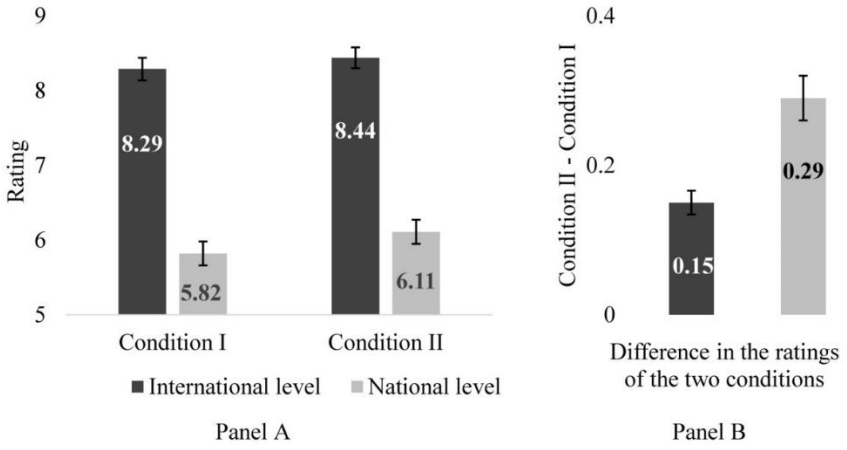

Fig. 1 Panel A: Mean ratings (with standard errors) of the athletes' performance in the two conditions depending on the athlete level. Panel B: Mean differences (with standard errors) of the ratings of the athletes' performance in the two conditions depending on the athlete level.

DISCUSSION

In AS, the dry-land drill is an important component both for trainings and competitions with athletes believing that it helps them to remember the routine they have to execute and trainers applying it in order for their athletes' performance in the water to get improved (Danardani et al., 2020). However, there is a shortage of research evidence supporting the common sense of the importance of this drill on athletic performance. Thus, this study attempted to investigate the impact of the dry-land drill on the performance of 47 AS female athletes. According to its results, the current study unequivocally corroborates, from a statistical point of view, that the established practice of performing a dry-land drill of the artistic swimming routine definitely benefits the athletes to subsequently perform the routine better in the water.

Differences in our participants' performance were not large; nevertheless, they were consistent and will definitely play an important role in the ranking of the athletes in national and international events. Our results are in alignment with Danardani et al. (2020), who also found that AS athletes improved their Free Routine Team scores after the implementation of a dry-land routine. The improvement in the performance brought about by the execution of a dry-land drill is more pronounced in younger athletes. This may be attributable to two factors: firstly, athletes of international level are more experienced and, secondly, their rating is already sufficiently high.

Artistic swimming has reached a high level of complexity, where the required figures, positions and movements have to blend together with the accompaniment of music into an artistic whole. The perfection of synchronization requires endless hours of repetition (Rodríguez-Zamora et al., 2014). To quote Mountjoy (2009): "In addition to the training required for the acquisition of sport-specific skills, artistic swimming athletes require additional training to perfect the precision of their movements. In most AS events, the athletes must synchronize their movements to each other. In the solo event of AS, athletes synchronize their movements to the rhythm, mood, and intensity of the music. At the elite level, an artistic swimmer trains in the water for 8-10 pool sessions per week including speed swimming, artistic swimming specific skills, fitness, and strength. Each training session is 2-4 hours in duration. In addition, they cross-train on land for 4-6 sessions/week, each session lasting 45-90 min in duration. The training pattern is high-volume and high-intensity, averaging approximately 40 hour per week" (p. 1,2). Moreover, Danardani et al. (2020) note that there is an escalation in AS athletes' beliefs regarding dry-land, with the younger (both in age and experience) ones recognizing dry-land as a type of exercise for remembering the routine choreography, the middle athletes understanding that it also helps them remember formation changes, and the seniors presenting a broader understanding and acknowledging the contribution of dry-land to the beauty of their routine.

This study has some limitations that should be taken into account when interpreting its results. Although female athletes aged 8-12 years participate in AS, in our sample only athletes aged 13 years and older took part; thus, we do not know how the dry-land could have affected the performance of those young swimmers. Moreover, this study focused only on a free team event. Consequently, questions regarding the importance of dry-land for the performance of athletes in solos or duets remain unanswered. However, to our knowledge this is the first study shedding light into this important issue in AS.

CONCLUSIONS

It seems that a final rehearsal through a dry-land drill evidently helps the athletes to embed the sequence in an effortless manner and provides them with confidence on the successful execution of the routine in the water. Furthermore, dry-land drills can be performed in conditions when practice in the water is not feasible because of an injury, bad weather conditions, during a journey, waiting at the changing room just before competition or to avoid training boredom. Especially with reference to addressing AS athletes' injuries and medical issues, in agreement with Mountjoy (2009), we underline the usefulness of dry-land as an effective alternative of their training in water, since, among other things, it offers a means for maintenance or/and improvement of synchronization that is an essential element of the AS routine. However, although this study provides research evidence about the importance of the dry-land drill, further research is needed so as qualitative training in AS to be informed.

In conclusion, the inferences acquired in the present study, through a controlled experimental procedure, provide verification that the established practice of execution of a dry-land drill before the final execution of the routine in the water is really beneficial.

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UTICAJ VEŠBI NA SUVOM NA PERFORMANSE SPORTISTKINJA U UMETNIČKOM PLIVANJU

Uobičajena je praksa među takmičarkama u umetničkom plivanju da izvode vežbu na suvom u svojoj rutini neposredno pre konačnog izvođenja u vodi. Potencijalne prednosti ovog utvrđenog postupka nikada nisu potvrđene na eksperimentalnoj osnovi. Ova studija je imala za cilj da pruži statističke dokaze koji potvrđuju značaj vežbi na suvom terenu. Četrdeset sedam grčkih sportista umetničkog plivanja (od kojih sedam nastupa za grčku reprezentaciju) dobilo je rutinu koja sadrži standardne figure, položaje i pokrete. Ova rutina je izvedena dva puta, sa i bez prethodne vežbe na suvom, izvedena nasumičnim redosledom sa pauzom od jedne nedelje između dva izvođenja. Tri međunarodne sudije su angažovane da ocenjuju performanse u standardna tri panela izvođenja, težine i umetničkog utiska. Ocene performansi uključujući vežbe na suvom bile su značajno bolje (upareni t-test, p<0,001) od onih bez njih. Ovo poboljšanje je bilo dosledno u svim kategorijama i nivoima sportista. Poboljšanje performansi koje je donelo izvođenje vežbe na suvom bilo je izraženije kod mlađih sportista. Poboljšanje performansi sportista kada izvode vežbu na suvom može igrati važnu ulogu u rangiranju sportista na nacionalnim i međunarodnim takmičenjima. Vežbe na suvom treba preporučiti kao standardni operativni postupak u umetničkom plivanju.

Ključne reči: *Umetničko plivanje, vežbe na suvom, performansa*