Effects of Eight Weeks Aquatic-Non-aquatic Training program on Aerobic Fitness and Physical preparation in junior Basketball Player

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Abstract: This study aims to determine whether aquatic training and Non-aquatic training can improve aerobic fitness, and physical preparation in younger basketball player. Eighteen basketball players (age=17.49±0.53 years, body mass=67.37±1.17 kg, height=179.30±1.46 cm, sport experience=3.40±0.36 years) participate in this study. The participants were randomly assigned to aquatic training group (AQT n=9) or Non-aquatic training group (NQT n=9) to perform eight weeks of aquatic-Non-aquatic exercise twice weekly for 45 min, both in addition to traditional preseason basketball training. The exercises included power skips, spike approaches, single- and double-leg bounding, continuous jumping for height, squat jumps with blocking form, and depth jumps. Basketball players were assessed before and after eight-week training period on VO2max, 20 m sprint, vertical jump, set and reach flexibility, 1RM leg press and curl-up, agility T-test. The results showed that the two groups made significantly improvements in all variables but the (AQT) made significantly improvements greater than (NQT). We conclude that the aquatic exercises resulted in larger improvements in aerobic fitness, VJ, sprint, flexibility, agility, strength and endurance than in the NQT group.
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1. Introduction

Basketball players need to generate good speed, agility and tremendous power during the play of game. The ability to generate maximal strength levels in the shortest period of time has been considered as essential to obtain high sport performance levels (Jose & Janeira, 2008). Physical and physiological characteristic are of utmost importance for Basketball players at any level of play. Optimal performance thus requires a combination of technical and tactical abilities as well as a high degree of physical fitness. (Yograj, 1997). Techniques like dribbling, passing, shooting, etc not only need skill but these skills should be enriched with physical and physiological determinants like anthropological measurements, aerobic capacity, strength, endurance & power of leg muscles, flexibility and agility. All these are dependent on each other.

Aerobic fitness is the ability to perform dynamic exercise using large muscle groups at moderate to high intensity for prolonged periods (ACSM 1995). VO2 max is considered to be the most valid measure of aerobic fitness. It measures the capacity of the heart, lungs, and blood to transport oxygen to the working muscles, and measures the utilization of oxygen by the muscles during exercise.

Athletes have tried different methods of improving their abilities of running faster and throwing an object higher and farther to the maximum possible extent. Perhaps one of the most successful methods is the one that involves plyometric exercises. In plyometric exercises, the sudden lengthening and shortening of muscle length by the contraction and stretching of muscles result in a rapid release of energy stored in the muscles, as a result of which these exercises simultaneously enhance three important abilities, i.e. power, speed, and endurance (Khorrami, 1997). Plyometric training is referred to as improving the most powerful motor performance skills in young basketball players (Fulton, 1992) and they are a significant component of most conditioning program designs. Plyometric training is often used during the off-season basketball training program, as an effective method for improving motor performance (Adkins et al., 2007).

Plyometric training can cause injury in various limbs, acute muscle soreness, muscle damage, or even musculoskeletal injuries (Jamurtas et al., 2000). This is guide researchers to choose optimum training surface plyometric exercise, with minimum injuries and improve performance. Some authors investigated the effects of different surfaces like sand, grass and wood on performance with reducing injuries (Impellizzeri et al., 2008). Others have recommended that plyometric training would be to perform in water, swimming pool or aquatic plyometric training (APT).

Water may reduce the pressure put on the musculoskeletal system because aquatic environment provides buoyancy that reduces weight bearing stress on the limbs. The viscosity and resistance to movement within the water requires additional muscle activation to overcome the resistance and produce the similarly movement that is more easily produced land or other surfaces.

Different studies compared the effects of aquatic and land plyometric training on power, vertical jump (VJ), speed, strength, agility and muscle soreness (Robinson et al., 2004; Martel et al., 2005; Shiran et al., 2008). Robinson et al. (2004) compared the effects of 8-week of APT vs. LPT on VJ, muscle strength, sprint velocity, and muscle soreness in healthy college-aged women. Both groups made significant increases in VJ, and sprint velocity. But, aquatic plyometrics provided significantly less muscle soreness. Martel et al. (2005) compared the combination of APT with traditional volleyball training. Both the APT and CON groups demonstrated significant improvements after the 6-wk study; however, the APT group had a significantly larger increase than the CON group for torque production in the during maximal knee-extension exercise. Shiran et al. (2008) compared the effects of 5-week of APT vs. LPT on physical performance in professional male wrestlers. The results indicated that APT provided the similar enhancement as LPT in physical performance with less muscle soreness. To our knowledge, no researches have addressed the effect of aquatic plyometric training on cardiorespiratory fitness and preseason preparation especially young basketball players. Therefore, the purpose of this study was to determine whether aquatic plyometric training can improve cardiorespiratory fitness, and physical preparation in young male basketball player. The researcher hypothesized that aquatic plyometric training would lead to greater improvements in cardiorespiratory fitness and physical preparation.

2. Material and methods

Subjects

Eighteen male junior basketball players (age 18±0.60 yrs.; body height 180.28±4.58 cm; body mass 75.66 ±3.93 kg; and sport experience 4.75±2.23 yrs.) voluntarily participated in this study. Subjects were randomly assigned to two groups; aquatic plyometric training (APT) group (n=9), and control (CON) group (n=9). The subjects were informed about the possible risks and benefits of the study and gave their informed consent to participate in this study. Before the study, none had participated in strength training or plyometric training involving the legs during that same time, and none of the subjects had ever participated in APT. The body height of the basketball players was measured using a stadiometer accurate to within 1 cm (SECA213, Germany), while electronic scales (Tanita BC 418, Japan) accurate to within 0.1 kg was used to measure body mass (Lohman et al., 1988).

Procedures

20-meter shuttle run test:

Cardio-respiratory fitness was estimated using the 20-meter shuttle run test. The test was carried out in a gym with a plane surface. The required speed was continuously increased every minute by 0.5 km/h. Subjects kept the required speed by completing every 20-meter stage within the sound of two beep sounds. The interval between these beeps was reduced every minute in order to elicit the speed increments. The velocity in the last stage completed by each subject was recorded and used to calculate the VO2máx in ml.kg -1min-1according to the equation validated by Léger et al. as follows: VO2máx = 31.025 + 3.238*velocity - 3.248*age + 0.1536*velocity*age (Léger et all., 1988).

Vertical jump test:

Vertical jump height, defined as the difference between standing reach height and the maximal jump height, was measured to the nearest 0.64 cm (0.25 inches) in all subjects at baseline. Each subject performed three trials with 1 min of rest in between each jump and the highest jump was used in the data analysis. The following procedure was used for each subject during data collection. The vertex was adjusted to match the height of the individual subject by having them stand with the dominant side to the base of the testing devise. Their dominant hand was raised, and the vertex was adjusted so that their hand was the appropriate distance away from the marker based on markings on the device itself. At that point, subjects performed a countermovement jump. Arm swings were allowed but no preparatory step was performed (Maffiuletti et al., 2002).

Maximum strength:

The 1-RM leg press assesses the maximum muscular strength of the major muscles of the lower extremity. Warm-up consisted of a set of five repetitions at the loads of 40-50 % of the perceived maximum. Leg press test was completed using standard leg press machine (NIROO, KING BODY). Subjects assuming a sitting position with back on padded supported and about 180˚ hips flexion, 80˚ knees flexion and 10˚ dorsiflexion at the ankles. The weight action line was obliquely at 45˚. On command, the subject performed a concentric extension (as fast as possible) of the leg muscles starting from the flexed position to reach the full extension of 180º against the resistance. Tester alerted the subjects when the starting and finishing positions were attained. Each subject was performed 2 maximal trails. Three minutes of rest was permitted between trials (Hamid and Abbas, 2011).

20-m sprint test: T

he sprint running tests were performed on an outdoor track. The sprint running test consisted of 3 maximal sprints of 20-m, with a 2-min resting period between each sprint. Sprint time was recorded using hand-held stopwatch (Joerex, ST4610-2). The subjects started the sprint when ready from a standing position start, behind the start line. On commend, subjects were instructed to sprint as fast as possible through the distance. The timer stood at the finish line (Markovic et al., 2007).

Agility T Test.

This test is the most appropriate agility test for basketball because it uses most of the basic movements performed during a game. The subjects were asked to sprint from a standing point in a straight line to a cone placed 9 m away. Then they had to side-shuffle to their left without crossing their feet to another cone placed 4.5 m away. After touching this cone, they side-shuffled to their right to a third cone placed 9 m away, side-shuffled back to the middle cone, and ran backward to position. The faster of 2 attempts was recorded (Seminick, 1990).

Sit-and-reach test:

Subjects removed their shoes and sat in the straight leg position with their feet flat against the sit-and-reach testing box. Subjects placed one hand on the other, with the middle fingers aligned and elbows extended. Subjects reached forward with their hands-on top of the sit-and reach box, as far as possible, without bending their knees. The feet were considered as zero, and each subject's score was recorded as the distance from the tip of the middle finger to the feet. Both positive and negative scores were thus measurable. Because we were interested only in the change in flexibility. The best of 3 trials was recorded (Nelson and Kokkonen, 2001).

Curl-up Test.

The subjects were positioned supine, with their knees flexed in a comfortable position. The knee flexion angles were not standardized because no specific angles were reported by Robertson and Magnusdottir (1987). The subject's feet were not held by an examiner during this test. They reached forward toward a frame positioned 7.62 cm away from their longest fingertip while lifting their upper back off the mat. The range of motion for this test was approximately the same as that tested isokinetically. The score was the number of times the subjects reached the frame in 1 min (Robertson and Magnusdottir, 1987).

Experimental design

Aquatic training program:

The AQT program was conducted twice a week for 8wk. in a swimming pool with a depth of approximately 122 cm and a temperature of 28°C. All AQT sessions were begun within 30 min after cessation of preseason basketball training sessions. Each AQT session lasted approximately 45 min, and consisted of a warm-up, AQT, and cool-down, all performed in the water. The warm-up consisted of approximately 5 min of light jogging in the water. The AQT exercises included power skips, spike approaches, single- and double-leg bounding, continuous jumping for height, squat jumps with blocking form, and depth jumps. The power skips, spike approaches, single- and double-leg bounding, and continuous jumping for height were all performed with maximal effort along the width of the pool (12.2 m) two times per session during the first week. These exercises were then performed along the width of the pool three times per session during the second week, four times per session for the third, fourth and fifth weeks, and five times for the sixth, seventh and eighth weeks. Bouts of continuous maximal squat jumps were performed three times (10 s of continuous jumps per bout, separated by 30-s recovery periods) per session during the first week, four times per session during the second week, four times per session during weeks 3,4 and 5 (increased from 10 to 20 s for each bout, separated by 30-s recovery periods), and four times per session during weeks 6, 7 and 8 (increased from 20 to 30 s for each bout). A series of depth jumps were performed involving three submerged boxes (61 cm in height) two times per session during week 1, three times per session for week 2, four times for weeks 3, 4 and 5. and five times for weeks 6, 7 and 8. The subjects began the depth-jump circuit by squat jumping from the pool floor onto the first box, then squat jumping without hesitation as high as possible and landing on the floor between the first and second box, at which point they immediately squat jumped as high as possible, landing on the second box. The subjects continued this pattern over the third and final submerged box and recovered while walking back to the beginning of the circuit. After recovering for approximately 30 s, the subjects began the next interval. The cool-down period consisted of approximately 5 min of walking in the water followed by static stretching of the major muscle groups of the legs.

Non-Aquatic training program:

The NQT program was conducted twice a week for 8 wk. with the same exercise which used with the AQT group (power skips, spike approaches, single- and double-leg bounding, continuous jumping for height, squat jumps with blocking form, and depth jumps. The power skips, spike approaches, single- and double-leg bounding, and continuous jumping for height) but the difference between them was the environment which used in the training.

Statistical analyses

All statistical analyses were performed using the SPSS version11.0 software (Statistical Package for Social Sciences; SPSS Inc., Chicago, IL, USA). A descriptiv statistics (mean ± SD) was calculated for all of the variables. The independent sample t-test was used to detect differences between the study groups (APT, CON) for all the baseline variables and identify any significant differences between the groups at the pre and post tests for the dependent variables. The paired sample t-test was used to detect differences between pre and post tests for each group. The level of significance was set at $P \leq 0.05$.

3. Result

There were no significant differences between AQT and NQT groups at pre-test. No injuries occurred throughout the study period, and the testing and training procedures were well tolerated by the subjects. Table 1 shows the results of aerobic fitness (VO2 max) and physical performance parameters for two groups in pre and post test phase. The results showed that there is a highly significant increase in VO2max and physical performance for AQT group. The Differences between pre and post measurements for AQT group are shown in Figure 1. The results also indicate that the NQT group improved their VO2max and physical performance, but these improved less than AQT. The Differences between pre and post measurements for NQT group are shown in Figure 2.

Table 1: ***Means, standard deviations (SD) and significant differences between pre and post- measurement for AQT, NQT groups in all the variables***.

Variable	Group	Pre-test	Post-test	Difference of mean	T value	P value
VO2max (ml/kg/min)	**AQT**	51.66±1.73	43±1.53	8.55	13.26	0.001*
	NQT	51.77±1.71	48.44±1.66	3.33	4.89	0.001*
Vertical jump (Cm)	**AQT**	44.55±1.13	52.77±1.78	8.22	-13.8	0.001*
	NQT	44.44±1.13	48.77±3.3	4.33	5.37	0.001*
20-m sprint (Sec)	**AQT**	3.88±.97	2.77±1.13	1.11	5.54	0.001*
	NQT	3.88±.78	3.22±0.7	0.66	4.30	0.001*
Sit and Reach (Cm)	**AQT**	13.11±1.45	15±1.41	1.88	-9.43	0.001*
	NQT	12.22±1.3	13.66±1.5	1.44	-5.25	0.001*
Agility T test (Sec)	**AQT**	11.66±1	9.66±0.5	2	8.48	0.001*
	NQT	11.44±.88	10.11±0.6	1.33	4.42	0.001*
1-RM leg press (kg)	**AQT**	13.11±1.05	15.88±1.05	2.77	-12.5	0.001*
	NQT	12.77±1.2	14.44±1.01	1.67	-6.63	0.001*
Curl-Up test (Nm)	**AQT**	52±1.87	58.33±1.5	6.33	-5.86	0.001*
	NQT	52.33±1.87	55.77±1.56	3.44	-3.83	0.001*

AQT: Aquatic training group ***NQT***: Non-aquatic training group *** P< 0.05**

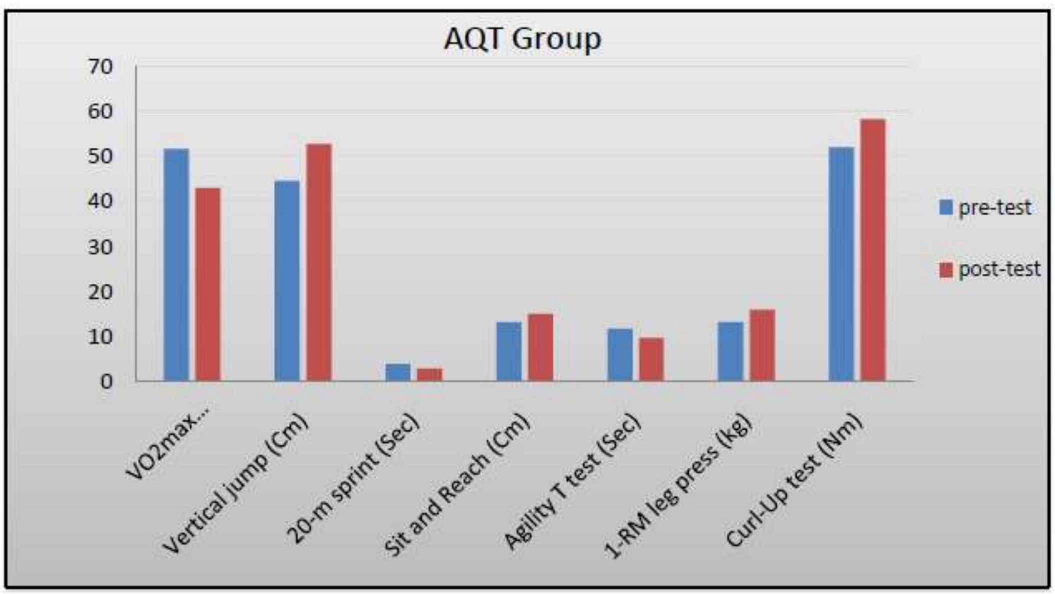

Fig.1: ***Differences between pre and post measurements for aquatic (AQT) group***

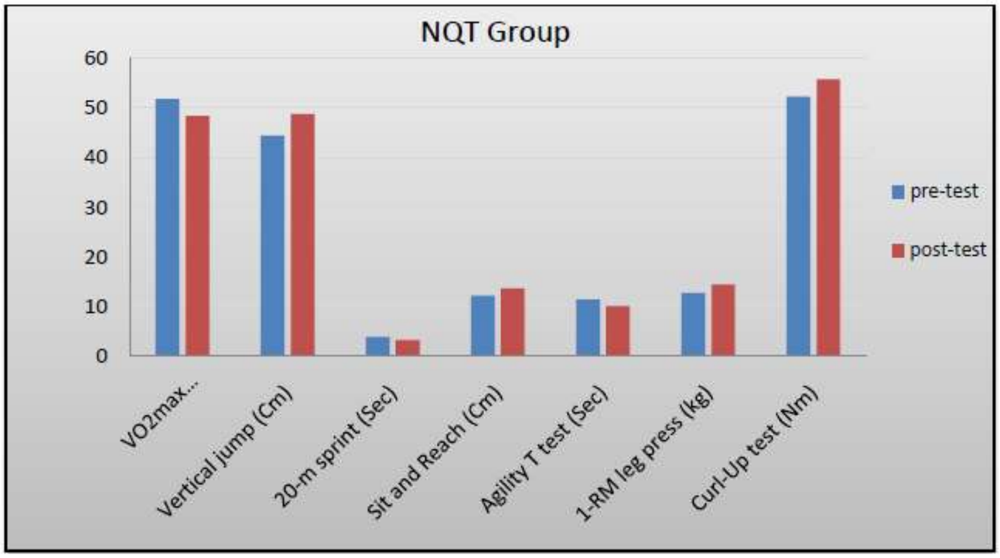

Fig 2: ***Differences between pre and post measurements for Non-aquatic (NQT) group***

Table 2 shows a significant difference between AQT, NQT groups After 8 weeks of aquatic-Non-aquatic training, the AQT group made significantly (P < 0.05) greater improvements than NQT group in all variables. The percentage of improvement in performance of the two groups is shown in Figure 3.

Table 2: *Means, standard deviations (SD) and significant differences in the post- measurement between the AQT, NQT groups in all the variables.*

Variable	AQT group	NQT group	Difference of mean	T value	P value
VO2max (ml/kg/min)	43±1.53	48.44±1.66	5.44	-7.72	0.001*
Vertical jump (cm)	52.77±1.78	48.77±3.3	4	5.58	0.001*
20-m sprint (sec)	2.77±1.13	3.22±0.7	0.45	-2.45	0.001*
Sit and Reach (cm)	15±1.41	13.66±1.5	1.34	2.94	0.001*
T Test Agility (sec)	9.66±0.5	10.11±0.6	0.45	-5.54	0.001*
1-RM leg press (kg)	15.88±1.05	14.44±1.01	1.44	6.04	0.001*
Curl-Up test (Nm)	58.33±1.5	55.77±1.56	2.56	7.69	0.001*

*** P< 0.05**

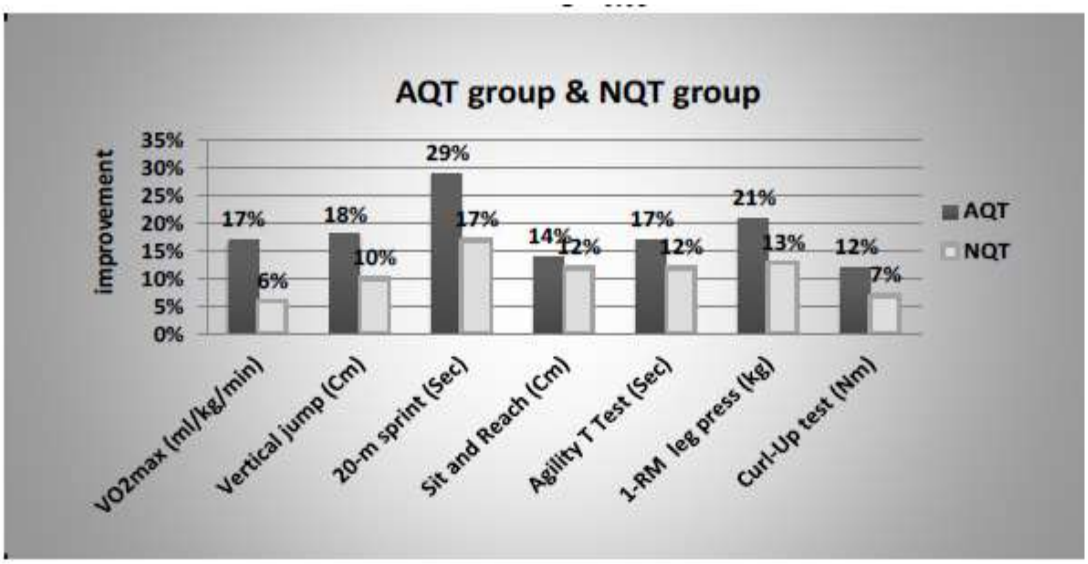

Fig. 3: *Percentage of improvement in performance of the AQT, NQT groups*

4. Discussion

The present study examined the effect of 8weeks of aquatic-Non- aquatic training on aerobic fitness (VO2max) and physical performance (vertical jump, 20m sprint, sit and reach flexibility, agility T-test, 1Rm leg press, and curl-up endurance). As hypothesized, aquatic training program resulted in significantly greater improvements in aerobic fitness and physical performance. The AQT group made significantly greater improvements in aerobic fitness (VO2max) (17% vs.6%) than the NQT group. The reason was 8 weeks strenuous training might have given adequate load on cardiovascular system of the subjects which might have enhanced their cardiovascular efficiency. Williams and Wilkins (2010) demonstrate that exercise of the intensity, duration, and frequency recommended here results in improvements in cardiorespiratory fitness. Young basketball players in the APT group made significantly greater improvements in lower body power which are usually seen as essential for basketball performance (Fulton, 1992). The AQT group made significantly greater improvements in the vertical jump height (18% vs.10%) than the NQT group. These results are in agreement with previous findings demonstrated by Robinson et al. (2004) found that participants who used aquatic training program had more significant increases in VJ with a reduction in muscle soreness than land. Additionally, Martel et al. (2005) demonstrated the ability to increase vertical jump in female volleyball players using specific aquatic plyometric training and these improvements could be accomplished with less muscle pain as well. This finding is in line with our study. Asadi and Arazi (2012) examined the effect of high-intensity plyometric training on vertical jump and sprint performance in young male basketball players. They reported that The PL demonstrated significant improvement ($P < 0.05$) in VJ (~23%) after a 6-week of training and compared to CG. Our study is in line with above study. The improvement in jump height indicates that adaptations relating to increases in leg power have occurred. Many authors suggested that muscular performance gains after plyometric training are attributed to a neural adaptation located in the nervous system (Maffiuletti et al., 2002; Potteiger et al., 1999). According to these authors, neuromuscular factors such as increasing the degree of muscle coordination and maximizing the ability to use the muscles' stretch-shortening cycle appear to be more important for the improvement in jump performance following plyometric training.

The current study indicated that aquatic training group (AQT) significantly improved performance in the 20-m sprint test (29% vs. 17%) compared to NQT group. This data concur with the findings by Asadi and Arazi (2012) reported that The PL demonstrated significant improvement in 20-m sprint after a 6-week of plyometric training and compared to CG. Hamid and Abbas (2011) demonstrated that the 8-week of aquatic and land training in young basketball players can enhance the sprint. Diallo et al. (2001) found a significant improved in the 20 m sprint after a 10-week plyometric training program. Our study is in line with above study. The aquatic plyometric training may enhance sprint ability, because the use of stretch-shortening cycles during plyometrics performance. It is likely that the greatest improvements in sprinting will occur at the velocity of muscle action that most closely approximates the velocity of muscle action of the plyometric exercises employed in training (Rimmer and Sleivert, 2000).

The current study indicated that aquatic training group (AQT) significantly improved performance in the sit and reach test (14% vs. 12%) compared to Non-aquatic training group (NQT).

The results indicate also the AQT group made significantly greater improvements in the agility T-test (17% vs.12%) than the NQT group. These results are in agreement with previous findings demonstrated by Michael et al. (2006) they found that the subjects who underwent plyometric training were able to improve their times significantly on agility T-test. Therefore, they found a positive relationship between plyometric training and improvements agility T-tests. Asadi and Arazi (2012) reported that The PL demonstrated significant improvement in agility T-test after a 6-week of plyometric training and compared to CG. Findings of Gulick et al. (2007) indicate that APT may be an effective alternative approach to enhancing agility. This finding is in line with our study. The plyometric training program may have improved the eccentric strength of the lower limb, a prevalent component in changes of direction during the deceleration phase (Sheffard and Young, 2006). It is well document that agility requires development of muscle factors (e.g., strength and power) to improve change of direction speed and it appears that, agility has high relationship with strength and power (Sheffard and Young, 2006). Perhaps increases in the power performance become one of the important variables for the enhancement of agility.

The results observed that maximal strength as measured by 1RM leg press was improved more by AQT (21% vs.13%) than by NQT and there was a significant difference between AQT and NQT groups. These results are in agreement with previous findings demonstrated by Hamid and Abbas (2011) reported that APT improved better than LPT in strength but there was no significant difference between APT and

LPT groups. Martel et al. (2005) reported that the APT group had a significantly larger increase than the CON group for torque production in the during maximal knee-extension exercise. This finding is in line with our study. The reasons for this similarity can be depth of water, volume, frequency, training period and total workload was equated between studies. Shiran et al. (2008) reported that 5-week of APT and LPT improved leg muscle strength in male wrestlers. Our study is in line with above study. With attention to, differences strength tests, sex, age, and training period. It seems aquatic and land plyometrics cause a tangible increase in the recruitment of motor units of agonist muscles and hence, improve the strength. Also, one may speculate that the muscle force stimulus experienced by previously physically active or moderately trained individuals during plyometric training can be effective for maximal strength development.

The results observed that muscular endurance as measured by curl-up was improved more by AQT (12% vs.7%) than by NQT and there was a significant difference between AQT and NQT groups. To our knowledge, a little study has addressed the effects of APT on endurance. Kamalakkannan et al. (2011) demonstrated that aquatic plyometric training can be one effective means for improving endurance. This finding is in line with our study. The reasons of increase muscular endurance can be the type of plyometric training exercises used, the training stimulus**,** correctly designed and competently supervised and training program carry no extra overload on young athletes' skeletal muscles as proved by the absence of injury during the training program. Also, none of the participants missed training practice or basketball games due to injury**.**

Conclusion

The major conclusion drawn from this study according to the results was that the combination of AQT and basketball training resulted in larger improvements in aerobic fitness, and physical performance parameters required for the preseason preparation. so, coaches may be needing to design aquatic training in the preseason preparation for young athletes, because this type of training can be effective for improving performance.

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