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Comparing the effects of aquatic and land-based balance training programs in male tennis players

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Abstract
Background: Balance training improves neuromuscular control and functional performance. Loss of balance is one of the most important cause of increased lower extremity injuries and increased risk of falls. Balance training reduces the recurrence of injury and it is important factor in avoiding errors while attempting to hit the ball in tennis.
Objectives: To compare the effects of aquatic and land-based balance training programs in male tennis players.
Study Design: Two group's comparative study Quasi- Experimental study design.
Subject: 30 male tennis players at new Woodlands Hotel.
Intervention: Group "A" received aquatic balance training whereas Group "B" received land balance training. Outcome
Measures: Unilateral stance test and STAR excursion balance test. Pre-test post-test scores were compared and results were tabulated.
Results: Both groups showed significant improvement in balance. The Group "A" showed statistically significant improvement in balance when compared to Group "A".
Conclusion: Aquatic based balance training was effective in improving static and dynamic balance.

Keywords: static balance, dynamic balance, ankle injuries, neuromuscular control, performance

Introduction

Balance is the ability of the body to maintain the line of gravity of a body within the base of support with minimal postural sway [1]. Sway is the horizontal movement of the centre of gravity even when a person is standing still. A certain amount of sway is essential and inevitable due to small perturbations within the body (e.g., breathing, shifting body weight from one foot to the other or from forefoot to rear foot) or from external triggers (e.g., visual distortions, floor translations). An increase in sway is not necessarily an indicator of dysfunctional balance so much as it is an indicator of decreased sensorimotor control. Maintaining balance requires coordination of input from vestibular, somatosensory and visual systems. Most authors defined neuromuscular training as multi-intervention programs with a combination of balance, strength, plyometric, agility, and sport-specific exercises. Functional improvements and decreased injury rates as a result of balance exercises are often discussed in association with adaptations in neuromuscular control mechanisms, such as proprioception or spinal reflex activity. Most investigators studied balance training, it seems likely that these exercises have a certain influence on neuromuscular control and functional performance [2].

This view is supported by research proving that poor balance is a predictor of increased lower extremity injury risk in athletes. It was also found that subjects who were unable to balance on one limb for 5 seconds had 2.1 times the risk of incurring an injurious fall as individuals who could balance for more than 5 seconds [3]. Some researches were conducted on 'Neuromuscular Training' which seems to be any type of training that focuses on proprioception. They concluded that there is good evidence that this type of training can reduce risk of sports injuries in young adult athletes during sports that require pivoting [4].

There were similar studies, conducted on the effect of 'Neuromuscular Training' for rehabilitation after sports injuries. The researchers concluded that this type of training can lower incidences of re-injury and giving way episodes after ankle sprain and knee ACL sprains [4]. Another study has shown that athletes in a hamstring rehabilitation program using strength/stretching exercises had a 70% chance of re-injury. But athletes using agility/stabilization exercises only had an 8% chance.70% vs 8%.In a meta-analysis of balance training and associated injury risks, six studies were examined and it was found that balance training reduced the incidence of ACL ruptures by 7-fold in male soccer players; however, it was also associated with a significant increase in the risk of major knee injuries in female soccer players as well as overuse 16 injuries in male and female volleyball players [25]. The study that found these results was the only study that used a wobble board in its training protocol and, therefore, the researcher suggests that differing methods of proprioceptive training might influence the rate of ACL injuries in a more positive manner [25]. Regarding dynamic balance, it was mentioned that Research in junior competitive tennis has shown that losing balance while hitting causes 80% of all errors. A study suggests that balance training is an effective means of improving joint proprioception and single-leg standing ability in subjects with unstable and non-impaired ankles [31]. According to an author, implementing a simple on-court balance training program improves neuromuscular control of a player and improve his state of equilibrium.

This in itself has substantial effect in performance and equilibrium [5]. The factors of hydrostatic pressure and

buoyancy allow exercise in an aquatic environment to have several advantages over a gravity-influenced environment [8]. This idea provides tremendous aid in rehabilitation settings when full weight bearing is contraindicated. Hydrostatic pressure provides compression to the body surfaces which will aid in decreasing edema for rehabilitative cases and increasing balance by increasing joint mechanoreceptor activity [26].

Methodology

- Study type : Experimental study
- Sample Size : 30 Male tennis players
- Sampling Method : Simple random sampling
- Study Setting : Woodlands Hotel, Mylapore
- Study Duration : 6 weeks

Materials Required

- Timer
- Inch tape
- Chalk piece
- Athletic tape

Fig 1

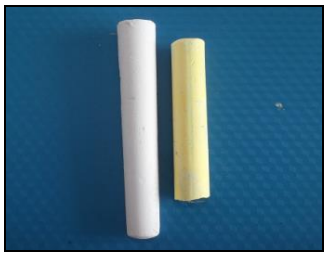


Fig 2

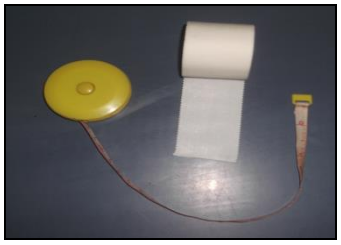


Fig 3

MeasuringTools

Static balance test

The unilateral stance test will be done by asking the subject to stand one lower limb and be in this position for as long as he can be without losing balance. This will be done on other leg as well. This will be done with eyes open and eyes closed. The values will be noted down.

Fig 4

Dynamic star excursion test

Before the test is performed, there is a set up needed. 4 strips of athletic tape with a length of 6-8 foot are needed. Then you should form a '+'. After this is done, another 4 strips of athletic tape of the same length but this time to form an 'x' are needed. It is important that all the different lines are separated from each other by an angle of 45 degrees [23, 24]. The goal of the SEBT is to maintain single leg stance on one leg while reaching as far as possible with the contra lateral leg. The person performing this test must maintain a base of support on one leg, while using the other leg to reach as far as possible in 8 different directions.

This person (standing on his left leg for example) must reach in 8 different positions, once in every of the following directions: anterior, anteromedial, medial, posteromedial, posterior, posterolateral, lateral and anterolateral. The anterior, posteromedial and posterolateral directions appear to be important to identification individuals with chronic ankle instability and athletes at greater risk of lower extremity injury.

When the person demonstrates a significantly decreased reach while standing on the injured limb compared to standing on the healthy limb, the Star Excursion Balance Test has shown his ability to point out a loss of dynamic postural control [23, 24]. There is a similar test like the Star Excursion Balance Test, but this test is not performed in the shape of a star, but in 'Y-form', called the Y-test.

The test originally incorporated reaching in eight directions while standing on each foot, but factor analysis indicated that one reach direction (posteromedial) was able to accurately identify individuals with chronic ankle instability as well as performing all eight directions [22].

Fig 5

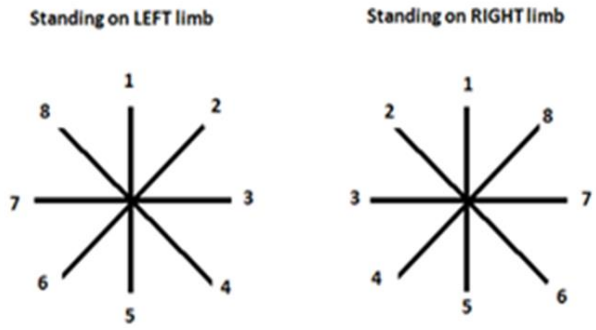


Fig 6

Procedure

This study was designed to investigate whether significant increases in balance in male tennis players when adding a 6 week balance training program. The relationship between tests was also investigated. The subjects (n=30) will be selected and divided into two groups-aquatic and land group. Both the groups receive the same balance training.Each group receives training thrice a week throughout 6 weeks each session lasting 30 minutes.

The exercises including heel walk, toe walk, lunge walk, squats, jumps, standing on one leg eyes closed and open. The land group receives this training on land and aquatic group receives this with 50% immersion in water.

The subjects were assessed with 2 tests for their static and dynamic balance. Unilateral stance and STAR excursion test.

Group A – Aquatic group

Group B – Land group

Group A: Aquatic based balance training group.

The aquatic based balance training group consisted of 15 male individuals who took up the Unilateral and STAR Excursion Balance tests before the starting the training protocol. Subjects in the aquatic based balance training group performed exercises in barefoot.

Safety measures were taken and lifeguards and first aid boxes were made available during the sessions. The training session lasted for 30 minutes for every player.

Group B: Land based balance training group.

The land based balance training group consisted of 15 male individuals. This group underwent the same training program on land. The Unilateral and STAR Excursion Balance tests were conducted again after the 6 weeks and the data were noted down. The subjects performed these exercises with their shoes.

Table 1: Exercise Protocol

S. No	Exercise	Repetitions	Sets
1.	Heel walk	30 steps	3 sets
2.	Toe walk	30 steps	3 sets
3.	Side walk	30 steps	3 sets
4.	Backward walk	30 steps	3 sets
5.	Squats	15 repetitions	3 sets
6.	Jumps	15 repetitions	3 sets
7.	Lunges	15 repetitions	3 sets
8.	Single leg standing (Eyes open)	30 counts	3 sets
9.	Eyes closed	30 counts	3 sets

Group A: Aquatic based balance training group

Figure 7-Heel Walk

Figure 8- Toe Walk

Figure 11 –Squats

Figure 12 -Jumps

Figure 9-Side Walk

Figure 10-Backward walk

Figure 13- Lunges

Figure 14-Single leg standing

Group B: land based balance training group

Figure 15- Heel Walk

Figure 16- Toe Walk

Figure 19-Squats

Figure 20 –Jumps

Figure 17-Side Walk

Figure 18-Backward Walk

Figure 21-Lunges

Figure 22-Single leg standing

Results

The statistical tools used in this study were Paired t-test and t-values were measured. The t value was measured in the analysis of comparison of both groups and paired t-test was for analysis of comparison between the pre-test and post-test means within groups.In table 1, the unilateral stance with eyes open, among Group A and B, Group A shows $p<0.05$ which shows there are significant improvement in values indicates an improvement after six weeks of balance training

In Table 1, the unilateral stance with eyes open, the Group A shows significant difference in the values.

COMPARISON BETWEEN PRE AND POST TEST SCORES OF UNILATERAL STANCE TEST IN AQUATIC AND LAND BASED BALANCE TRAINING GROUPS

UNILATERAL STANCE TEST-RIGHT AND LEFT LEGS WITH EYES OPEN

GROUP	PRE TEST	POST TEST		
	Mean ± SD	Mean ± SD	Paired t-value	P value
Aquatic based balance training group (right)	163.4±102.6	211.7±103.6	6.86*	p<0.05
(left)	133.1±75.4	181.93±86.7	4.82*	p<0.05
Land based balance training group (right)	227.60±93.9	240.87±87.6	1.834^{NS}	p>0.05
Left	184.13±79.1	200.13±79.2	1.86^{NS}	p>0.05
Right	t value is $-.832^{NS}$, p>0.05			
Left	t-value is $.600^{NS}$, P>0.05			

*- denotes significant, ie p<0.05 and NS- Not significant .ie, p>0.05

In table 2, unilateral stance test with eyes closed, Group A showed $p<0.05$ on both legs. However Group B showed $p>0.05$ which indicates an improvement in Group A after six weeks of balance training.

Table 2: Comparison between pre and post test scores of unilateral stance test for balance with eyes closed

	Pre Test	Post Test		
Group	**Mean ± SD**	**Mean ± SD**	**Paired t-value**	**p-value**
Aquatic based balance training group(right)	33.2 ± 21.4	75.40 ±41.16	6.52*	p<0.05
Aquatic (left)	22.20 ± 20.8	64.93 ± 23.45	7.41*	p<0.05
Land based balance training group (right)	111.45 ± 62.3	120.93 ± 66.67	1.99^{NS}	p>0.05
Land based balance training group(left)	65.71 ± 55.0	73.53 ± 56.06	3.23*	p<0.05
Right -Between group comparisons using unpaired t-test		t-value is 2..251^{S}, p<0.05		
Left- between group comparisons using unpaired t-test		t-value is. 548^{NS}, p>0.05		

*- denotes significant, ie p<0.05 and NS- Not significant. ie, p>0.05

In Table 3 the pre-test and post-test values of STAR excursion balance test in group A were compared and were found to be p<0.05. According to this table p<0.05 which shows an improvement

Table 3: Comparison between pre and post test scores of star excursion balance test on distance in aquatic based balance training group

Position	Pre test	Post test		
	Mean ± SD	**Mean ± SD**	**Paired t-value**	**p-value**
Center (right)	125.3 ± 16.9	129.5 ± 16.0	7.26*	p<0.05
Center (left)	157.5 ± 18.9	131.8 ± 18.8	7.24*	p<0.05
Anteroleft (right)	126.5 ± 12.8	130.7 ± 11.3	4.48*	p<0.05
Anteroleft (left)	127.1 ± 14.3	131.7 ± 13.0	5.13*	p<0.05
Anteroright (right)	129.4 ± 13.8	133.1 ± 12.8	4.63*	p<0.05
Antetroright (left)	128.6 ± 17.3	135.0± 15.3	5.46*	p<0.05
Right dir (right)	130.5 ± 11.9	135.9 ± 11.1	7.84*	p<0.05
Right dir (left)	131.9 ± 15.6	135.7 ± 14.7	4.37*	p<0.05
Left dir (right)	123.1± 18.9	129.3 ± 15.6	4.63*	p<0.05
Left dir (left)	127.2 ± 11.9	131.9 ± 10.2	8.77*	p<0.05
Posterior (right)	124.00 ± 17.6	130.4 ± 15.9	4.43*	p<0.05
Posterior (left)	126.33 ± 16.7	132.9 ± 15.0	4.93*	p<0.05
Posterioright (right)	125.47 ±12.3	130.4 ± 15.9	1.36^{NS}	p<0.05
Posterioright (left)	125.87 ± 13.6	132.9 ±15.0	2.52*	p<0.05
Posterioleft (right)	125.80 ± 10.01	129.0 ±10.5	6.06*	p<0.05
Posterioleft (left)	125.13 ± 16.9	132.3± 13.6	4.03*	p<0.05

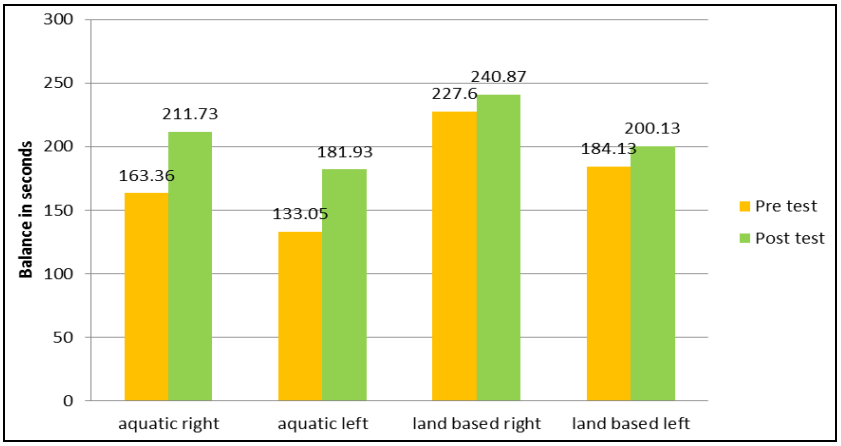
*- denotes significant, ie p<0.05 and NS- Not significant. ie, p>0.05

In table 4, the pre-test and post-test values of STAR excursion balance test were compared in Group B were compared. According to this table, p>0.05 showed that there is no significant difference in the land training group.

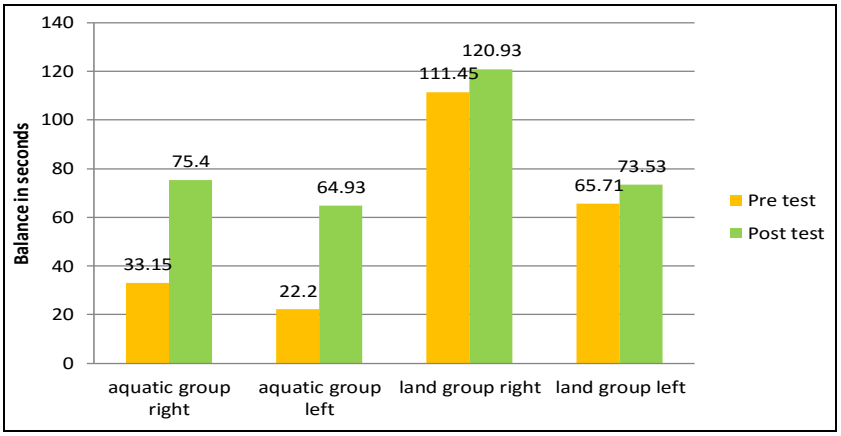
Table 4: Comparison between pre and post scores of star excursion test on distance in land based balance training group

Position	Pre-test			Post-test				
	range	**Mean**	**SD**	**range**	**mean**	**SD**	**Paired t value**	**P value**
Center (right)	94-134	115.40	12.29	95-135	116.47	12.21	1.83^{NS}	p>0.05
Center (left)	100-132	118.13	8.97	102-133	118.80	8.80	2.32*	P<0.05
Anteroleft (right)	96-129	113.27	10.13	96-129	113.73	9.779	1.70^{NS}	p>0.05
Anteroleft (left)	105-133	121.40	8.43	107-133	122.00	7.89	1.59^{NS}	P>0.05
Anteroright (right)	98-140	119.73	11.10	100-140	120.53	10.94	3.29*	p<0.05
Antetroright (left)	95-152	117.00	16.810	96-152	117.67	16.25	2.19*	p<0.05
Right dir (right)	100-144	120.87	11.831	100-147	121.67	12.134	2.56*	p>0.05
Right dir (left)	98-151	123.60	15.688	98-153	124.13	15.620	2.77*	P>0.05
Left dir (right)	98-136	113.13	11.550	98-136	113.93	11.209	2.70*	p<0.05
Left dir (left)	103-132	121.93	9.346	102-133	122.53	9.219	1.41^{NS}	p<0.05
Posterior (right)	105-150	126.40	9.97	106-150	126.73	9.93	2.09^{NS}	p>0.05
Posterior (left)	100-152	129.33	13.52	102-152	129.47	13.52	0.56^{NS}	P<0.05
Posterioright (right)	98-153	125.33	15.823	106-150	126.73	9.932	0..36^{NS}	p>0.05
Posterioright (left)	109-156	127.80	14.042	102-152	129.47	13.522	0.50^{NS}	P>0.05
Posterioleft (right)	94-141	119.87	14.040	94-141	120.53	13.851	2.00^{NS}	p>0.05
Posterioleft (left)	114-143	128.80	9.571	114-143	129.07	9.415	2.25*	p<0.05

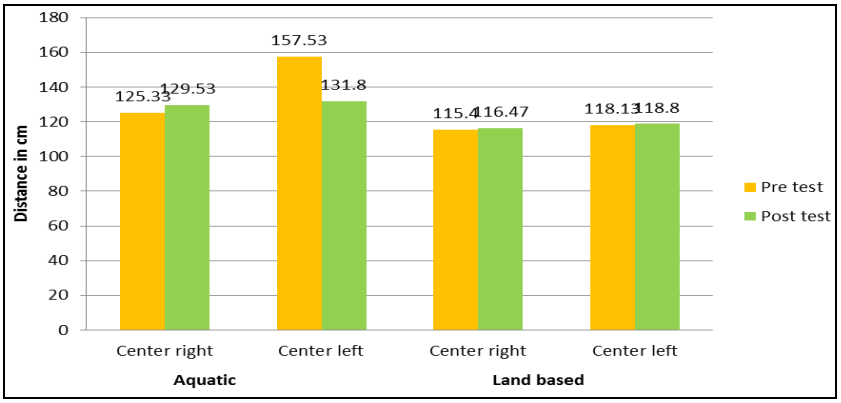
From graph 3.1-3.7, the post-test values of the STAR excursion balance test show that there is a significant difference in the values in Group A but no significant difference in Group B in six weeks of balance training.



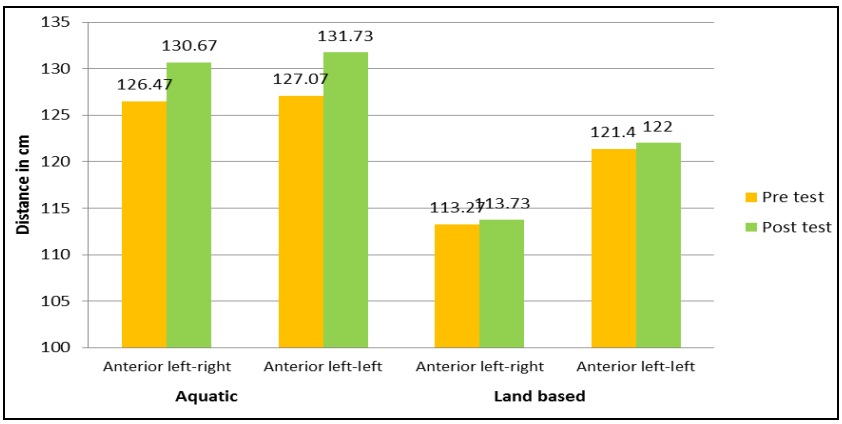
Graph 1: Pre and post-test means of balance in seconds of right and left with open eye in both groups



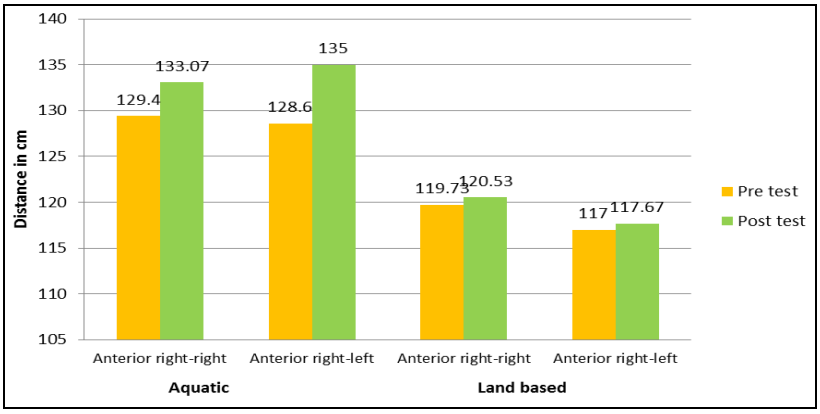
Graph 2: Pre and post-test means of balance in seconds of right with eyes dosed in both groups



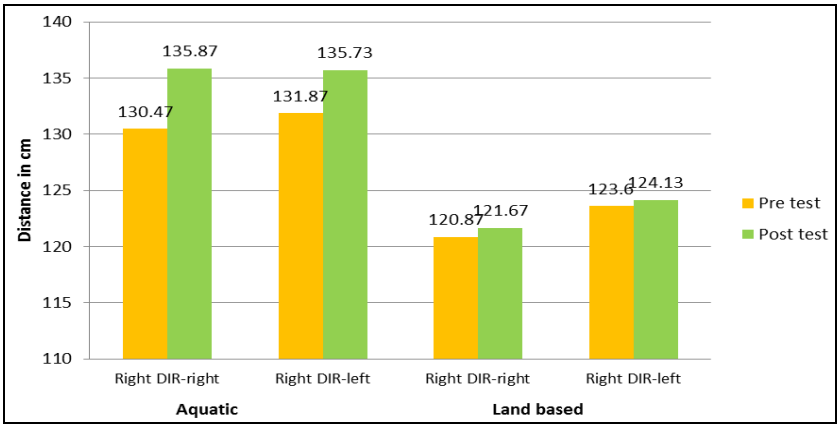
Graph 3.1: A Pre and post-test means of score on distance in centimeters over different position in both groups (Center).



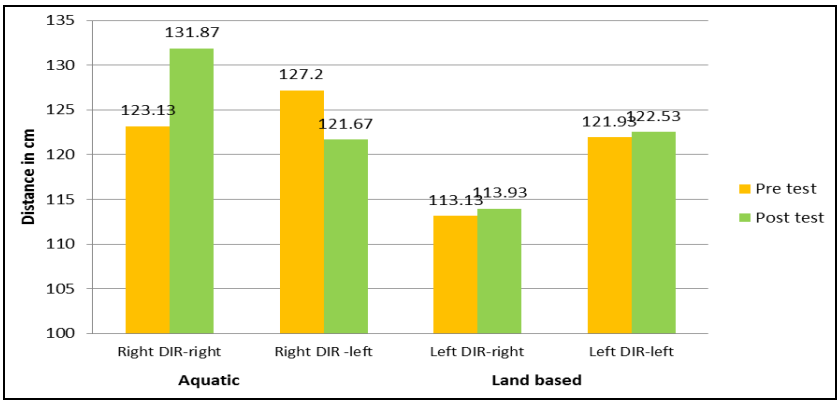
Graph 3.2: A Pre and post-test means of score on distance in centimeters over different position in both groups (Center).



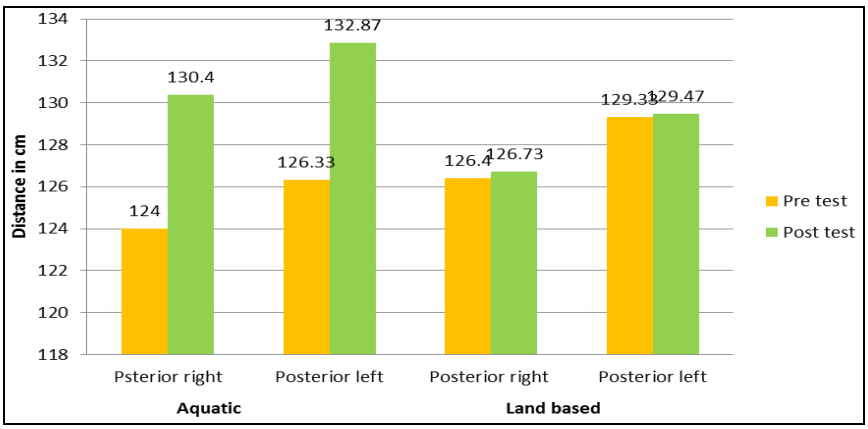
Graph 3.3: A Pre and post-test means of score on distance in centimeters over different position in both groups (Center).



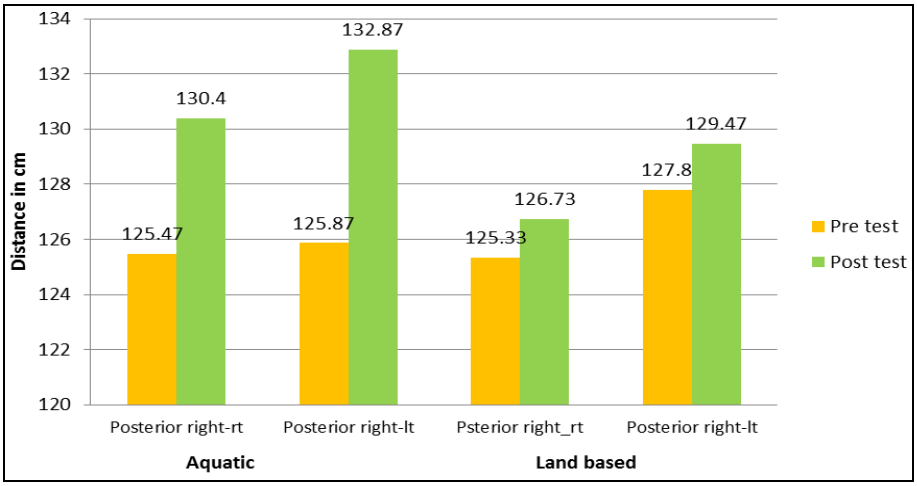
Graph 3.4: Pre-test and post-test means of score on distance in centimeters over different position in both groups(Right direction)



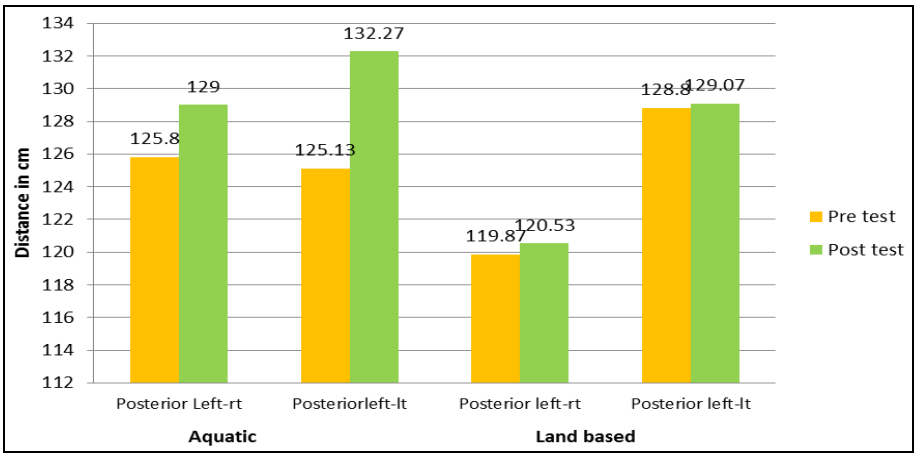
Graph -3.5: Pre-test and post-test means of score on distance in centimeters over different position in both groups(L eft direction)



Graph 3.6: Pre-test and post-test means of score on distance in centimeters over different position in both groups (Posterior)



Graph 3.7: Pre-test and post-test means of score on distance in centimeters over different position in both groups (Posterior right)



Graph 3.8: Pre-test and post-test means of score on distance in centimeters over different position in both groups (Posterior left)

Discussion

A common cause of injuries is often poor balance. Research in junior competitive tennis players has shown that losing balance while hitting causes 80% of all errors. A number of studies have found that poor balance ability is significantly related to an increased risk of ankle injuries, other ligamentous and muscular injuries in different activities. This relationship appears to be more common in males than females. Multifaceted intervention studies that have included balance training along with jumping, landing and agility exercises have resulted in a significant decrease in ankle or knee injuries in team handball, volleyball and recreational athletes.

It is unknown which component of the multifaceted intervention was most effective and whether the effects are additive. As a single intervention, balance training has been shown to significantly reduce the recurrence of ankle ligament injuries and other injuries in soccer, volleyball and recreational athletes; however, it has not been clearly shown to reduce injuries in athletes without a prior injury. Balance training on its own has also been shown to significantly reduce anterior cruciate ligament injuries in male soccer players [25].

This study was conducted to determine the balance improvement in Tennis players after implementing a balance training program. Balance was assessed by unilateral stance test and STAR excursion balance test. Subjects with no injury and history of surgery were taken for the study with 15 subjects in each group. The results of this study showed that there is significant improvement in balance among subjects who underwent an aquatic based balance training program.

These results were similar to WhiteHill *et al* who concluded that the though land based balance training and aquatic groups had significant effects, greater improvements in agility and balance were measured [16]. Roth *et al* suggests that a possible increase in balance following aquatic based balance exercises could be the increase in the strength of the lower limb musculature which leads to enhanced balance improving performance also reducing the risk of injuries[8]. Kristine Amii suggested that aquatic exercises were efficient in improving the lower extremity strength and balance in older adults [20]. According to Hamid Assadi and Abbas Asadi, the 8 week of plyometric exercises in aquatic and land training were effective in improving strength, balance, sprint but they say plyometrics might have risk of injuries [12]. During the study, we encountered difficulties like convincing the players for aquatic therapy. Some subjects of land training group were travelling often and we found it difficult to reach them everywhere they went.None of the players opted out of the study.

The players were enthusiastic about the training sessions and found both the training sessions very useful. Some players were aware of few exercises but were not doing those exercises on everyday basis. The land training group reported a more stable equilibrium and better neuro-muscular control. They reported to have less frequent falls. The players responded to the aquatic training sessions

positively.Initially the aquatic training group found it difficult to balance in water but got better later. They reported less injuries, better balance and an efficient performance in the game. Performance was not measured in the study as our scope restricts to balance. So, further studies must take these points into consideration.

Conclusion

The present study concluded that the 6 week program of aquatic based balance exercises and land based balance exercises in male tennis players showed significant differences in the pre and post testing sessions. Hence the study reveals that the aquatic based balance programs are more effective in improving the static and dynamic balance.

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