

Effect Of Aquatic Therapy on Vo2 Max Among Handball Players – A Pre-Post Experimental Pilot Study

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ABSTRACT

Context: Handball is a game that requires optimal physical fitness with moderate to high aerobic demands. **Aquatic therapy generates a distinct "training effect" that enhances both work capacity and maximal oxygen consumption (VO2 max).** The study aims to determine the effect of aquatic therapy on VO2max among handball players.

Design: The study was a pre post study conducted on handball players. **Methods:** The sample size was ten and the participants were approached through convenience sampling. National or state level handball players between the age of 18-27 years were approached and included in the study. The outcome measures evaluated pre and post intervention were VO2 max assessment, throwing accuracy and vertical jump. The intervention included aquatic therapy- water based specific exercises.

KEYWORDS: Handball, VO2 max, Aquatic therapy

INTRODUCTION:

Handball is a high-intensity sport that involves a lot of physical contact and rapid movements, which can put players at risk for a variety of injuries. The prevalence of injuries in handball players varies depending on several factors such as age, gender, level of play, and playing position. Based on a systematic review of injury surveillance studies conducted on handball players, the collective incidence rate of injuries in handball was determined to be 3.7 injuries per 1,000 player-hours. The primary types of injuries reported were acute traumatic injuries, including sprains and strains, which accounted for 33.4% of the cases, followed by overuse injuries such as tendinopathies and stress fractures, which constituted 23.2% of the injuries observed^{1,2}.

Several factors influence the performance of handball players, including physical fitness, technical skills, tactical knowledge, psychological factors, nutrition, and vo2 max. Physical fitness, including aerobic endurance, maximal strength, and speed, is a significant predictor of handball performance, with vo2 max being an essential factor in aerobic endurance. Vo2 max is a measure of maximal oxygen uptake and transport, reflecting the player's aerobic capacity³.

Physical fitness is an important factor in the performance of handball players. In team handball, aerobic capacity is crucial because players must exert constant effort over the course of the 60 -minute match, involving actions such as running back and forth on the court to facilitate ball movement. Aerobic and strength training can help improve physical fitness, as well as proper recovery and nutrition. A variety of training methods, including interval training and strength training can be used to improve their physical fitness⁴.

ACSM defines maximum oxygen uptake, or VO2 max, as the highest quantity of oxygen an organism can consume within a given timeframe during exercise. It is important to note that an increase in exercise intensity does not necessarily result in a proportional increase in oxygen consumption. Ideally, as the workload progressively intensifies, oxygen consumption should reach a plateau, indicating the achievement of VO2 max. Many authors consider VO2 max as the most reliable indicator of an organism's aerobic capacity, reflecting the functional capabilities of the cardiovascular and respiratory systems, as well as the tissue's ability to utilize oxygen. Furthermore, it serves as a valuable measure of physical capacity of athlete⁵.

Assessment of VO2 max can be done using maximal and submaximal exercise tests, field tests, and indirect measures such as heart rate response to exercise. Maximal exercise tests involve measuring oxygen uptake during progressive exercise until exhaustion. The most commonly used protocols are the treadmill and cycle ergometer tests. These tests are considered the gold standard for measuring VO2 max, as they provide a direct measurement of the amount of oxygen consumed during exercise. The treadmill running test is the most commonly used laboratory method for assessing VO2 max. It involves the use of a motorized treadmill with adjustable speed and incline settings. The duration of the test is designed to allow for the maximization of cardiovascular responses. Typically, maximal tests utilizing continuous exercise protocols are conducted for a duration of 6 to 12 minutes. This timeframe allows for adequate stress on the cardiovascular system and enables accurate measurement of VO2 max^{5,6}.

VO2 max, which quantifies the maximum amount of oxygen an individual can consume during exercise is influenced by various factors such as genetics, age, gender, and training status. Ultra-endurance athletes had an average VO2 max of 63.5 mL/kg/min, surpassing the average VO2 max of elite athletes in various other sports. Vo2 max is the highest among soccer players compared to other sports players. The VO2 max of elite ice hockey players were found to be lower than the average VO2 max of elite athletes in other sports such as distance running and cross-country skiing. Finally, a study comparing the VO2 max of Olympic athletes from different endurance sports found that soccer had the highest VO2 max, followed by basketball, then hockey and volleyball. These findings demonstrate that VO2 max can vary significantly between different sports and can be used to assess the cardiorespiratory fitness of athletes from different disciplines^{6,7}.

The treatment of VO2 max primarily involves exercise training interventions aimed at improving aerobic capacity. Some common approaches that improve VO2 max are (A) Endurance training: Endurance training programs are designed to incorporate regular and sustained aerobic exercises, such as running, cycling, or swimming, at a moderate intensity for extended durations. The primary goal of such training is to enhance the cardiovascular system's capacity to efficiently deliver oxygen to the muscles, while also improving the muscle's ability to utilize oxygen for energy. (B) High-intensity interval training (HIIT): HIIT involves engaging in short bursts of high-intensity training followed by rest period or low-intensity training. Research has indicated that HIIT can lead to notable improvements in VO2 max within a shorter timeframe compared to traditional endurance training methods^{8,9,10}.

Aquatic therapy is another common approach to improve VO2 max. Aquatic therapy involves performing exercises in a pool, which can reduce the impact on joints while still providing resistance to movement. Aquatic therapy refers to a range of activities performed in water that facilitate rehabilitation and aid in the recovery process following intense exercise or significant injuries. This therapy aims to relax muscles, improve joint motion, and alleviate pain. Engaging in aerobic exercises induces a unique "training effect" characterized by specific cardiovascular adaptations. These adaptations include a decrease in resting and submaximal workload, an enhancement in work capacity, and an elevation in maximal oxygen consumption (VO2 max)¹¹.

Some benefits of aquatic therapy for improving VO2 max include Reduced joint stress: The buoyancy of water reduces the weight placed on joints during exercise, making it an ideal option for individuals with joint pain or injuries. Increased resistance: The resistance provided by the water can be used to increase the intensity of exercises, improving cardiovascular fitness and VO2 max. Improved lung function: Breathing exercises performed in the water can help improve lung function and increase the amount of oxygen delivered to the body. Enhanced recovery: Aquatic therapy can also be used as a form of active recovery, which can improve circulation and promote healing. aquatic therapy can be an effective and low-impact approach for improving VO2 max for individuals with joint pain or injuries, a combination of these approaches can help improve VO2 max and overall exercise performance^{12,13}. The resistance offered by water during limb movements in aquatic exercises creates a unique workout load that results in increased muscle tension and higher energy expenditure compared to land exercises. This additional resistance can account for the substantial improvement in VO2 max observed with aquatic exercises¹⁴.

Aquatic therapy is a form of physical therapy that involves exercises performed in a pool or other aquatic environment. It has been used as a treatment approach for various musculoskeletal conditions in sports, including handball. A study conducted an assessment of the impact of aquatic therapy on handball players with shoulder impingement syndrome, specifically focusing on shoulder pain and range of motion. The findings indicated that aquatic therapy program resulted in significant improvements in both shoulder pain and range of motion, surpassing the progress observed in a control group that did not undergo any intervention¹⁵.

In another study, the effects of aquatic plyometric training on lower limb muscle power and agility in handball players were investigated. The results demonstrated that a 6-week aquatic plyometric training program led to noteworthy enhancements in both lower limb muscle power and agility when compared to a control group that did not partake in any intervention. This highlights the potential benefits of aquatic plyometric training for enhancing physical performance in handball players¹⁶.

These findings suggest that aquatic therapy can be an effective treatment approach for handball players with various musculoskeletal conditions and may help improve performance-related outcomes such as muscle power and agility. This study determines the effect of aquatic therapy on VO2max among handball players. The secondary objective is to measure the effect of aquatic therapy on throwing accuracy and vertical jump of the handball players.

METHODS:

Study Design: Pre-Post experimental study.

Study Participants: Handball player

This research received ethical clearance from the institutional research board. Handball players were approached to participate in the study by convenience sampling. The sample size of the study was ten. The inclusion criteria for the study were: State/National level handball players between the age of 18-27 years. Both males and females were included

in the study. Players who had hydrophobia, Skin diseases, acute respiratory and cardiac illness, chlorine allergy, recent injuries, ear infections were excluded. The subjects were screened and an informed consent was taken prior to participation in the study.

Procedure:

Water temperature in the pool was 30degree C. Pre and post evaluation of outcome measures were conducted.

Outcome measures:

Vo2 max- Cardiovascular fitness is a crucial aspect of health. The gold standard for measuring it is maximum oxygen uptake (VO2max), which is typically used. The VO2max is a crucial measure used by professional athletes to evaluate the status and advancement of their training. The maximum rate of pulmonary oxygen uptake during exercise including a sufficient amount of muscle mass is referred to as VO2max. VO2max can be precisely determined in a scientific setting by employing incremental exercise program, typically on treadmill or a bicycle ergometer.

Throwing Accuracy – The player begins in a seated position behind a line, located 6 meters away from the target. The objective is to throw towards the center of the target with the utmost precision, and a successful throw is considered valid only if it hits the target. The player has five attempts to achieve the highest possible accuracy, and the most accurate throw among the five attempts is recorded. To prevent fatigue, a break of 1 minute is provided between each throw. The target consists of a square measuring 0.80 cm x 0.80 cm. From the center of this square, eight concentric circles are drawn with radii of 5, 10, 15, 20, 25, 30, 35, and 40 cm, respectively. The accuracy of the throws was evaluated based on a declining score system, where a grade of 8 corresponds to hitting the 5 cm radius circle, and a grade of 1 corresponds to hitting the 40 cm radius circle. The scoring system follows the pattern of assigning grades 8, 7, 6, 5, 4, 3, 2, and 1 to the respective circles in order of decreasing radius size.

VERTICAL JUMP- The athlete begins by standing beside a wall and extends their arm closest to the wall, reaching as high as possible. The point of the fingertips at this maximum reach is marked or recorded, known as the standing reach height. Next, the athlete steps away from the wall and performs a vertical leap, utilizing both arms and legs to propel themselves upward. The jumping technique may or may not involve a countermovement. The objective is to touch the wall at the highest point of the jump. The score is determined by calculating the difference in distance between the standing reach height and the height reached during the jump. The athlete is allowed three attempts, and the best score among the three is recorded.



FIGURE 1: VO2 Max Testing

Intervention:

The warm-up phase includes exercises such as high knee lifts, high knee jogs, ankle reaches, longer kicks, cross country skis, and jumping jacks in water.

Aerobic exercises in water: Deep water running (6 min), Deep water cycling (6 min), Shallow to deep water running (6 min), Squat jumps, Hops, Shuffles, Change in direction, single leg jump, double leg jump, high knee action (12min)

This was followed by a cool down phase for 5 minutes



FIGURE 2: High knee jogs

RESULTS:

Table 1: Demonstrated mean and standard deviation of age difference

	N	Mean	Standard Deviation	Minimum	Maximum
Age	9	19.44	2.30	18.00	25.00

9 subjects with a mean age (SD) of 19.44 (2.30) years were recruited for this study.

Table 2: Demonstrated mean and standard deviation difference of Pre-Post Vo2 Max values

	N	Mean	Std. Deviation	t-value	p-value
VO2 Max (Pre) (mL/min/kg)	9	32.489	6.597	5.037	.001**
VO2 Max (Post) (mL/min/kg)	9	41.878	7.013		

Table 2 shows mean $\pm$ SD for pre (32.489 ± 6.597) and post (41.878 ± 7.013) intervention respectively with significant p- value 0.001

Table 3: Demonstrated mean and standard deviation difference of Pre-Post vertical Jump values

	N	Mean	Std. Deviation	t-value	p-value
Vertical Jump (Pre) (CMs)	9	45.833	4.294	10.823	.0001**
Vertical Jump (Post) (CMs)	9	49.944	4.586		

Table 3 shows mean $\pm$ SD for pre (45.833 ± 4.294) and post (49.944 ± 4.586) intervention respectively with significant p- valve 0.0001

Table 4: Demonstrated mean and standard deviation difference of Pre-Post Throwing Accuracy values

	N	Mean	Std. Deviation	t-value	p-value
Throwing accuracy (Pre)	9	7.111	0.782	.686	.512
Throwing accuracy (Post)	9	7.333	0.707		

Table 4 shows mean $\pm$ SD for pre (7.111 ± 0.782) and post (7.333 ± 0.707) intervention respectively with non-significant p- valve 0.512

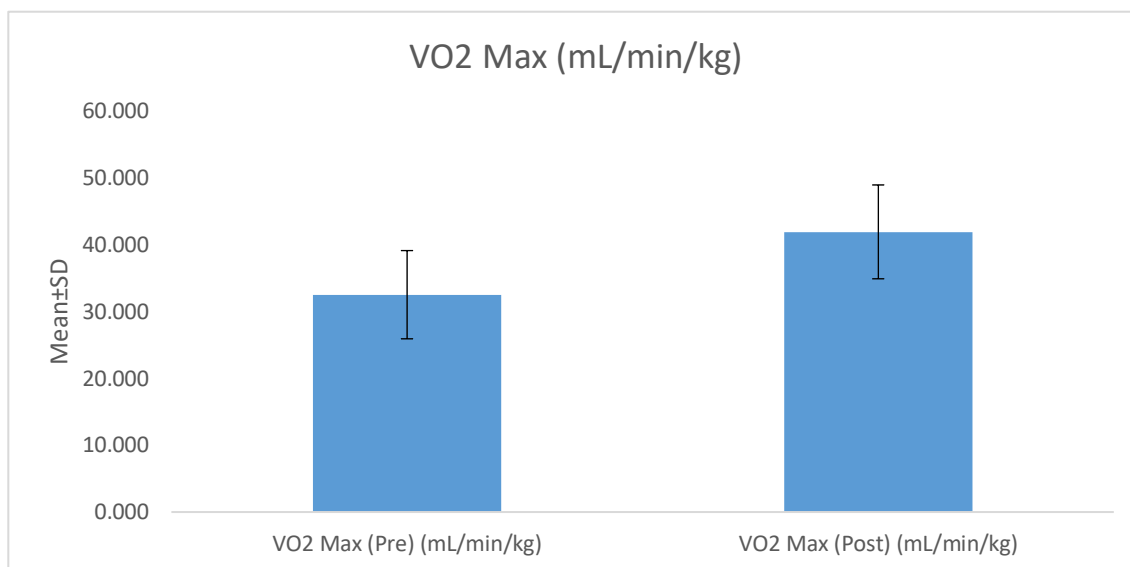


Figure 1: Vo2 max difference Graph

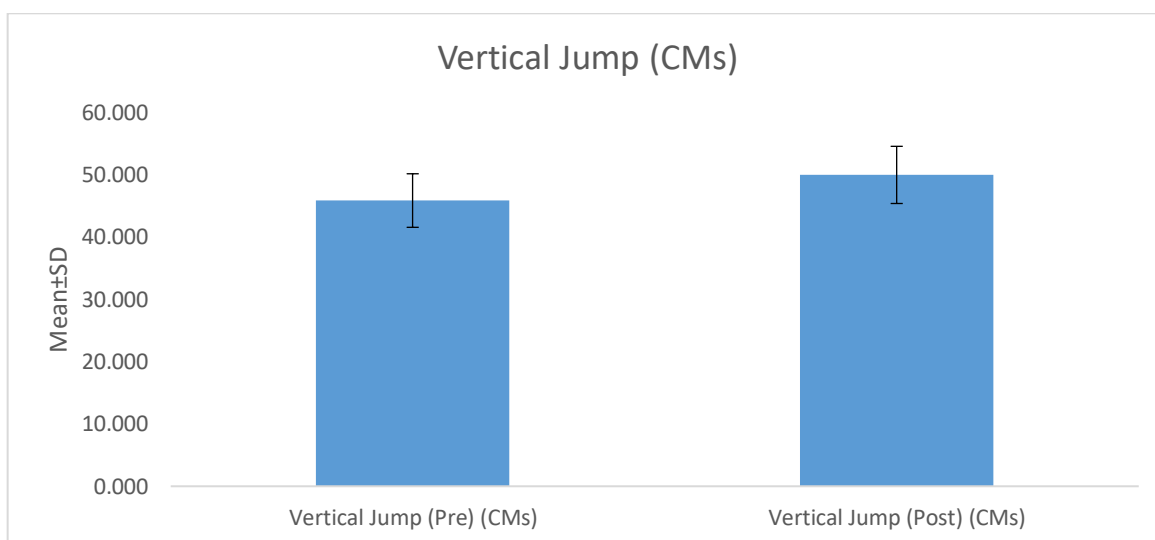


Figure 2: Vertical Jump Difference Graph

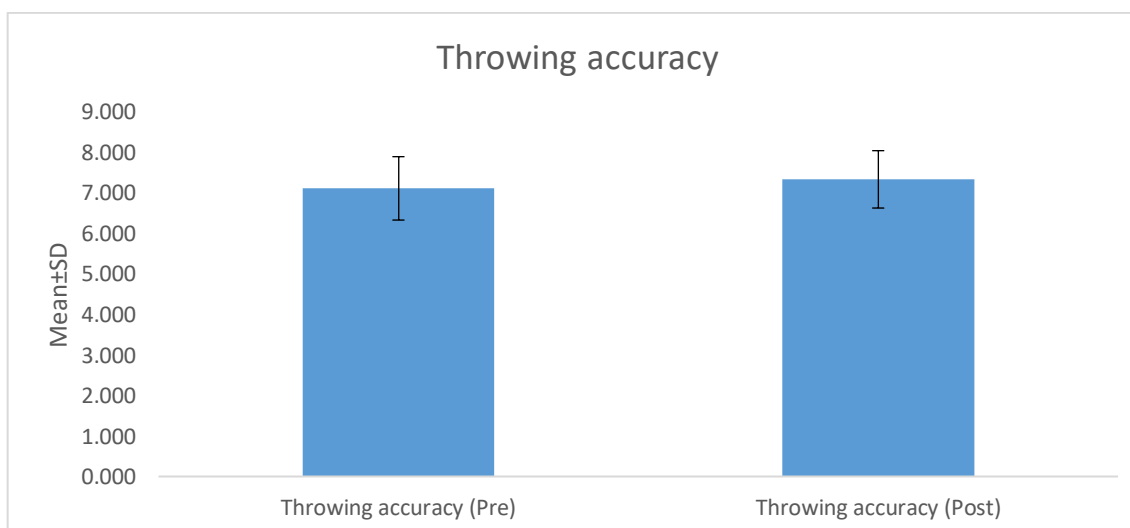


Figure 3: Throwing Accuracy Difference Graph

DISCUSSION

This study investigated the effect of aquatic therapy on VO₂ max among handball players. The study employed a pre-post experimental design to evaluate the changes in VO₂ max following the aquatic therapy intervention.

The study initially included ten state and national-level handball players with one dropout recorded resulting in nine players completing the study with mean age of 19.44 ± 2.30 years. All participants were actively involved in handball training and competitions.

The participants engaged in a 14-session aquatic exercise protocol, consisting of aerobic exercises performed over two weeks, with sessions conducted seven days a week. The warm-up phase incorporated exercises such as high knee lifts, high knee jogs, ankle reaches, longer kicks, cross country skis, and jumping jacks in water. The intervention phase included a range of aerobic exercises in water, including deep water running, deep water cycling, shallow to deep water running, as well as specific exercises like squat jumps, hops, shuffles, change in direction, single leg jump, double leg jump, and high knee action. The cool-down phase involved exercises lasting for 5 minutes.

The results of the data analysis demonstrated a statistically significant difference in VO₂ max following the two-week aquatic therapy protocol. The mean difference in VO₂ max was found to be 9.389 ml/kg/min (t-value = 5.035, p-value = 0.001). This significant improvement in VO₂ max suggests that the aquatic therapy intervention had a positive impact on the participant's cardiorespiratory fitness. The increase in VO₂ max indicates an enhancement in the athlete's aerobic capacity, which is crucial for sustaining performance during handball matches that involve intermittent bursts of high-intensity activity. The improvement in VO₂ max can be attributed to the specific aerobic exercises performed in water during the intervention phase. Activities such as, deep water running, deep water cycling, and shallow to deep water running engage large muscle groups and demand increased oxygen uptake in such a way water provides resistance to respiratory and cardiac muscles in human body which itself provides a conditioning effect on cardio respiratory system. The buoyancy and resistance provided by the water creates a challenging yet supportive environment for cardiovascular training.

The study conducted by Asmaa M. El-Bandrawy et al. showed similar results in which regular aquatic exercises in addition to relaxation training were effective in improving VO₂ max. Similar study was conducted by Ellen Broach et al. on oxygen consumption, Strength and endurance testing which stated that aquatic therapy improves and maintains health daily life functioning and physical capacity. Study conducted by Pereira et al. on effect of aqua aerobics on cardiovascular states that Aqua aerobic exercises increase cardiovascular endurance. Our study echoed with all these results and hence enhanced aerobic capacity resulting from the aquatic therapy intervention can have significant implications for handball players. A higher VO₂ max allows players to sustain intense physical efforts for longer durations, leading to improved endurance and performance during matches. The ability to efficiently utilize oxygen can also facilitate faster recovery between bouts of intense activity, enabling players to maintain a high level of performance throughout a game.

Overall, the statistically significant increase in VO₂ max observed following the two-week aquatic therapy intervention suggests that incorporating aquatic exercises into the training regime of handball players can be an effective strategy for enhancing their aerobic capacity. The findings support the alternate hypothesis and suggest that aquatic therapy can be an effective method for improving VO₂ max in handball players.

In addition to the improvement in VO₂ max, the study also found a statistically significant increase in vertical jump performance among the handball players. The mean difference in vertical jump was 4.111 cm (t-value = 10.823, p-value = 0.0001). This finding is consistent with previous research conducted by Nisith K.Datta et al. with similar results on physical fitness variables namely speed, leg explosive power showing Aquatic plyometric training significantly improved on speed, leg explosive power greater than that of land plyometric and control group, indicating that aquatic exercises can enhance lower body explosive power and muscular strength. The exercises used in the protocol such as squat jump, single leg jump, double leg jump, hops mimic the vestibular exercises performed on land with additional benefits of water such as buoyancy, resistance provided by the water acts as additional component over the vestibular exercises which would have brought these changes. The increased muscular power and explosiveness observed in the vertical jump can be advantageous for handball players, as jumping ability plays a crucial role in actions such as blocking, shooting, and reaching for rebounds.

However, the study did not find a significant effect of the aquatic therapy protocol on throwing accuracy among the handball players. The mean difference in throwing accuracy was only 0.222 (t-value = 0.686, p-value = 0.512), and the p-value did not reach statistical significance. These results indicate that while the intervention positively impacted cardiovascular fitness and lower body explosive power, it did not directly translate into improvements in throwing accuracy. Handball throwing accuracy is a complex skill that depends on various factors, including throwing technique, throwing mechanics, coordination, upper body strength, precision and mind component. It is possible that the short duration of the intervention or the limited focus on upper body exercises within the aquatic therapy protocol did not provide sufficient stimuli for improvements in throwing accuracy.

Vo2 max in current scenario has proven to be improved through circuit training, Plyometric training, Combined Endurance, Strength and Sprint Training. A study on The Effects of Circuit Strength Training on the Development of Physical Fitness and Performance-Related Variables in Handball Players conducted by Souhail Hermassi et al. states that circuit strength training program is an effective method to increase vo2 max in handball players. J. Jensen et al. in a study on the Effect of Combined Endurance, Strength and Sprint Training on Maximal Oxygen Uptake, Isometric Strength and Sprint Performance in Female Elite Handball Players showed significant improvements in maximal oxygen uptake. Wagner et al. in a study on Specific Physical Training in Elite Male Team Handball showed significant improvement in the endurance of the handball players. Alexiou vasilios et al. showed similar results in soccer players increase of VO2 max variation and the specific biochemical parameters after a pre-season training program. Study conducted by Nisith K. Datta et al on Effect of Aquatic and Land Plyometric Training on Selected Physical Fitness Variables in Intercollegiate Male Handball Players showed similar results in vo2 max improvement.

Our study concludes that aquatic therapy can serve as an effective adjunctive treatment and intervention for enhancing VO2 max, lower limb power, and performance in handball players.

CONCLUSION

A two-week pre-post study on aquatic therapy demonstrated improvements in VO2 max and vertical jump performance among handball players. These findings highlight the potential benefits of incorporating aquatic exercises into the training regime of handball athletes, particularly in terms of cardiovascular fitness and lower body explosive power. However, further research is needed to explore the impact of aquatic therapy on other factors influencing handball performance.

FUTURE RECOMMENDATIONS

Further research could be done by including a larger and more diverse sample, extending the duration of the intervention, RCT with a control group with standard protocol, land versus aquatic or combination of both can be compared. Aquatic therapy in combination with mind-based approaches can be compared. Examining the effects of aquatic therapy on other performance parameters relevant to handball is advised. Future research could explore the integration of upper body exercises specific to handball throwing mechanics, strength training within an aquatic therapy program to determine if it yields greater improvements in throwing accuracy. Functional throwing strength by isokinetic device, speed by radar gun can be functional outcome parameter in future research.

LIMITATION

The sample size was relatively small, and the study duration was limited to a two-week intervention period. Additionally, the study focused solely on male handball players and distribution of female players was none in this study, limiting the generalizability of the findings to other populations or sports.

REFERENCE

1. Martín-Guzón I, Muñoz A, Lorenzo-Calvo J, Muriarte D, Marquina M, de la Rubia A. Injury Prevalence of the Lower Limbs in Handball Players: A Systematic Review. *Int J Environ Res Public Health*. 2021;19(1):332.
2. Luig P, Henke T. Acute Injuries in Handball. European Handball Federation; 2011
3. Wagner H, Finkenzeller T, Würth S, von Duvillard SP. Individual and team performance in team-handball: a review. *J Sports Sci Med*. 2014;13(4):808-16.
4. Jensen J, Jacobsen ST, Hetland S, Tveit P. Effect of combined endurance, strength and sprint training on maximal oxygen uptake, isometric strength and sprint performance in female elite handball players during a season. *Int J Sports Med*. 1997;18(5):354-8.
5. Bundy M, Leaver A. Training and conditioning. A Guide to Sports and Injury Management. Churchill livingstone; 2010: 1-9
6. Rankovic G, Mutavdzic V, Toskic D, et al. Aerobic capacity as an indicator in different kinds of sports. *Bosn J Basic Med Sci*. 2010;10(1):44-8.
7. Mishra MK, Pandey AK, Chaubey D. A Comparative Study of Vo2 Max among the Basketball, Football, Volleyball and Hockey Male Players. *International Journal of Applied Research*; 2015: 245-247
8. Montero D, Lundby C. Refuting the myth of non-response to exercise training: 'non-responders' do respond to higher dose of training. *J Physiol*. 2017;595(11):3377-87.
9. Lundby C, Montero D, Joyner M. Biology of VO2 max: looking under the physiology lamp. *Acta Physiol (Oxf)*. 2017;220(2):218-28
10. Buchheit M, Simpson MB, Al Haddad H, Bourdon PC, Mendez-Villanueva A. Monitoring changes in physical performance with heart rate measures in young soccer players. *Eur J Appl Physiol*. 2012;112(2):711-23.

11. Mohamed IM, Magdy MAS, Hassan OG, Ahmed A. Response of VO2 max and pain tolerance to aquatic exercise and relaxation training in premenstrual syndrome. EurAsian Journal of BioSciences; 2020: 5049-5056
12. Becker BE. Aquatic therapy: scientific foundations and clinical rehabilitation applications. PM R. 2009;1(9):859-72.
13. Broach E, Dattilo JP. Aquatic Therapy: A Viable Therapeutic Recreation Intervention. Therapeutic Recreation Journal; 1996: 213-229
14. Severin C, Burkett B. Biomechanical aspects of aquatic therapy: a literature review on application and methodological challenges. Journal of Fitness Research; 2016: 48-62
15. Gliga AC, Neagu NE, Popoviciu HV, Bataga T. Effects of Adding Aquatic-to-Land-Based Physiotherapy Programs for Shoulder Joint Position Sense Rehabilitation. Healthcare (Basel). 2022;10(2):332.
16. Datta NK, Bharti R. Effect of Aquatic and Land Plyometric Training on Selected Physical Fitness Variables in Intercollegiate Male Handball Players. International Journal of Sport and Health Sciences. 2015;Vol:9: 449-451