## CHAPTER II

# REVIEW OF RELATED LITERATURE

The survey of related literature enables the researcher to identify the possibilities in his field. It helps him acquaint himself with a contemporary edge in the field in which he will conduct his research. The review of related literature can help the researcher to avoid work on unnecessary areas. It provides the research worker with an opportunity of gaining insight into the methods, measures, subjects. It is employed by other researchers, which will lead to significant improvement in his research design. The final and vital reason for reviewing the related literature is to know about previous researchers' recommendations. The review of related literature is for a better understanding of the problem and to interpret the results. The researcher has gone through all the available literature, which is relevant to this study. Findings and facts, including interpretations and explanations from the published literature, have been included in this chapter. The researcher collected the latest literature relating to this study by using libraries and internet facilities.

The review of related literature has been presented under the following headings;

1. Studies on Aquatic training
2. Studies on Sand training
3. Studies on Bio-motor variables
4. Studies on Physiological variables
5. Studies on Skill Performance variables

## 2.1 STUDIES ON AQUATIC TRAINING

**R. Anista, Dr. P. Sivagnanam&Dr.S.Arumugam (2018)** initiated research to evaluate the effects of "Aquatic training" on teenage boys' agility and strength. The

age of boys was between 12 to 14 years. The boys slipped into two groups, Group I – that participated in Aquatic training and Group II –acted as the control group. Group I underwent the training for six days a week, one session every day, and one session are for 45 minutes. Group II did not participate in any training; they just did their regular exercise. "10 meters of shuttle run test was done to measure the agility of boys, and the pushup tests were done to test the strength. The data was collected pre and post the test on a specific standard before and after the training. Once the data is collected, it is statically valuated by the dependent "t-test" and "Analysis of Co-Variance (ANCOVA)" for every selected variable independently. After Aquatic training, the result shows that the group I had remarkable development in agility and strength; on the contrary, Group II did not change their agility and strength.

**Ajayaghosh M.V. (2017)** studied the effects of Aquatic plyometric training for 12 weeks by randomly selected players. From the age group of 20-25 years of old, split into two groups. "Group 1" took the Aquatic plyometric training, whereas group 2 does not attend any specific training instead of regular exercises. The independent variable selected was "Aquatic Plyometric" training; on the other hand, the dependent variables that were chosen were "Speed and Explosive leg power." Uniform test items as 50 meters "Dash and Sargent Jump" were used to measure all the dependent variables. To identify the considerable mean difference, "Analysis of Covariance (ANCOVA)" needs to be applied. Test the level of significance, a confidence level of "0.05" was confirmed. The study outcomes show that the players' speed and explosive leg power got improved remarkably by the Aquatic plyometric training of 12 weeks.

**Cristine Lima Alberton. et al. (2014)** conducted a study on "Maximal and Ventilatory Thresholds Cardiorespiratory Responses to Three Water Aerobic

Exercises Compared With Treadmill on Land."This study aimed to assess maximal cardiorespiratory responses and ventilatory threshold (VT) for treadmill running (TR) and water-based stationery running (SR), jumping jack (JJ), and front kick (FK), and to compare the ratings of perceived exertion (RPE) corresponding to the 1st and 2nd VT. The sample included nine young women who participated in four maximal test sessions (TR, SR, JJ, and FK). A Polar S610™was used for heart rate (HR) measurement, a MedicGraphics VO2000 gas analyzer for oxygen uptake (VO2) and ventilation (Ve), and a Borg scale (from 6 to 20) for RPE. Repeated-measures ANOVA with post-hoc Bonferroni test was performed, with an = 0.05. The analyses showed that peak VO2 ($p<0.001$), maximal HR ($p=0.016$), and VO2 corresponding to VT ($p<0.001$) yielded significantly higher responses for TR, followed by SR and FK, and lower reactions for JJ. The percentage values of peak VO2 in the thresholds were not significantly different among the exercises. RPE also did not differ among exercises in the 1st and 2nd VT. Regardless of the exercise (TR, SR, JJ, or FK), the intensity will be the same if prescribed based on the percentage values obtained for VT or RPE.

**Paulo C. Bento, Maria de., et al. (2014***)* determined the "Effects of water-based exercise on body balance of elderly women." Physical activity for older adults is important because of the improvement in the quality of life. This study aimed to analyze the body balance in older women subjected to water-based exercise training. The sample consisted of 10 healthy active women (61.0 + 0.5 years) engaged in water for at least 12 months and at least three months without physical exercise. The subjects were divided into 3 groups: balance (n = 3), strength (n = 4) and aerobic (n = 4). The 12- week training was conducted at the Swimming Centre of the Physical Education School on the Universidade Federal do Rio Grande do Sul (EsEF /

UFRGS). Evaluation sessions were held, pre-and post-training, to assess body balance, where it was measured on an AMTI Brand force platform, with eyes closed and with eyes open. Data was collected on the center of plantar pressure variables anteroposterior ( COPx), plantar pressure center lateromedial (COPy), a moment of force anteroposterior (Mx), and moment of force lateromedial (My). Data analysis used descriptive statistics, and data are presented as mean and standard deviation. As a result, there was a trend for improvement in lateromedial balance in the aerobic group through the values of My with eyes open (0.08 ± 0.06 0.03 ± 0.03 pre and post) as well as in the strength group in the variables My and COPy (0.04 ± 0.02 0.02 ± 0.01 pre and post, 0.07 ± 0.09 0.04 ± 0.06 pre and post, respectively) and without My with closed eyes ( 0.03 ± 0.02 before and 0.02 ± 0.01 post). In the balance group, we found a trend of improvement in balance when considering the values of Copy with open eyes (0.06 ± 0.02 before and 0.02 ± 0.02 post). We conclude that the applied training improved some postural balance components post-training. This improvement was present regardless of whether the class applied to balance muscle strength or cardiorespiratory fitness.

**Jae Hyun Jung, Eun Jung Chung., et al. (2014)** reported the effects of Aquatic exercise on patients' pulmonary function with spinal cord injury. The subjects were randomly allocated to an aqua group (n=10) and a land group (n=10). [Methods] Both groups trained for 60 minutes, three times a week, for eight weeks. Pulmonary function was assessed by measuring the forced vital capacity (FVC), forced expiratory flow rate (FER), forced expiratory volume at one second (FEV1), and forced expiratory volume at one second/forced vital capacity (FEV1/FVC). [Results] Following the intervention, the aqua group showed significant changes in FVC, FER, FEV1, and FEV1/FVC. The land group showed only significant differences in FER.

The results of this study suggest that the aqua group's effects were significantly higher than those on the land group in patients with spinal cord injury.

**Hamid and Arazi (2011)** investigated the Effect of Aquatic and Sand Plyometric Training on Strength, Sprint, and Balance in Young Basketball Players. The purpose of this study was to compare the effect of eight weeks of Aquatic and Sand plyometric training on leg muscle strength, thirty-six and sixty meters sprint times, and dynamic balance test in young male Basketball players. Eighteen young male soccer players (age=18.81±1.46 years, height=168.34±6.11 cm, body mass=67.80±9.52 kg, sport experience=4.8±2.47 years) volunteered in this study and were divided into three groups; Aquatic plyometric training (APT), Sand plyometric training (LPT), and control group (CON). Experimental groups trained; ankle jumps, speed marching, squat jumps, and skipping drills for eight weeks and three times a week for forty min. The data were analyzed by one-way analysis of variance with repeated measures, a Tukey post hoc testing, and an independent-sample t-test. The results showed that there were not any significant differences between the APT and LPT groups in any of the variables tested ($P>0.05$). In post-training, significant increases were observed, both APT and LPT groups, in thirty-six and sixty-meter sprint times compared to pre-training ($P<0.05$). There was a significant difference in relative improvement between the APT and CON in thirty-six, sixty meters, and one-repetition maximum leg press ($P<0.05$). They concluded that plyometric water training could be an effective technique to improve young athletes' sprint and strength.

**KatsuraY. et al. (2010)** documented the Effects of Aquatic exercise training using water-resistance equipment in the elderly. However, resistance training for the

elderly induces muscle damage. Recently, Aquatic exercise using water buoyancy and resistance have commonly been performed by the elderly. We have now produced new water-resistance equipment. The purpose of the present study was to evaluate the efficacy of Aquatic exercise training using the new equipment for the elderly. Subjects were divided into two groups: a resistance group of 12 subjects (using water-resistance equipment) and a non-resistance group of eight subjects (without the equipment). The Aquatic exercise training was 90 min, three times per week for eight weeks, and mostly consisted of walking. All subjects underwent anthropometric measurements, physical performance testing, and a profile of mood states (POMS). Significant improvements were observed in muscle strength in plantar flexion and the timed up and go test (TUG) in both groups.

Additionally, 10-m obstacle walking and 5-m maximum walking speed and length with eye-open were significantly improved in the resistance group. A low negative correlation was found between the degree of change in TUG and POMS (tension and anxiety) scores in the resistance group. As it became easier to maintain posture, stand, and move, tension, and anxiety in everyday life were alleviated with improved strength of the lower extremities and balance function. The present Aquatic exercise training using water-resistance equipment may be used by the elderly to improve balance and walking ability, associated with the prevention of falls.

**Haupenthal A. et al. (2010)** made a study on Loading forces in shallow water running in two levels of immersion. To analyze the ground reaction force's vertical and anteroposterior components during shallow water running at two immersion levels. Twenty-two healthy adults with no gait disorders who were familiar with Aquatic exercises. Subjects performed six trials of water running at a self-selected

speed in chest and hip immersion. Force data were collected through an underwater force plate, and running speed was measured with a photocell timing light system. Analysis of covariance was used for data analysis. Vertical forces corresponded to 0.80 and 0.98 times the subject's body weight at the chest and hip level, respectively. Anteroposterior forces reached 0.26 and 0.31 times the subject's body weight at the chest and hip level, respectively. As the water level decreased, the subjects ran faster. No significant differences were found for the force values between the immersions, probably due to variability in speed, which was self-selected. When thinking about load values in water running, professionals should consider the immersion level and the speed, affecting the force components, mainly the anteroposterior one. Quantitative data on this subject could help professionals to conduct safer aqua-tic rehabilitation and physical conditioning protocols.

**K. Kamalakkannan, N.Vijayaragunathan, and R.Kalidasan. (2010)** identified the Influence of Aquatic training on selected physical fitness variables among volleyball players. The purpose of this study was to analyze the Aquatic training on selected physical fitness variables among volleyball players. To achieve this, 40 physically active and interested undergraduate engineering volleyball players were selected as subjects, and their ages ranged between 18 and 20 years. The subjects were categorized into two groups: the control group and the Aquatic training group with every 20 subjects. The experimental group underwent the experimental treatment for 12 weeks, three days per week, and a session each day with 45 min duration. Speed, endurance, and explosive power were taken as variables for this investigation. Fifty meters run, cooper 12 min run, and standing vertical jump were used as a test. The data collected before and after the experimental treatment was analyzed using an analysis of covariance (ANCOVA). The result revealed that the

Aquatic training group shows significant improvement in all the selected physical fitness variables.

**Orna A. Donoghue. et al. (2010)** found the Impact forces during land and Aquatic plyometric exercise. Buoyancy reduces impact forces during water-based exercise, making Aquatic plyometrics a safer alternative to land-based plyometrics. This study quantified the reduction in impact forces during several jumping exercises using force plates positioned on land and in a swimming pool at a water depth of 1.3 m. Peak impact forces were reduced by 33-54% across the various exercises ($p<0.001$). Single leg hops resulted in relatively higher impact forces than forces absorbed by each leg during double leg jumps on land; however, these forces were comparable during Aquatic jumps. The results have implications for coaches and therapists who use Aquatic plyometrics in training or rehabilitation.

**William M. Denning (2010)** distinguished the Reliability of Peak Cardiorespiratory Responses During Aquatic Treadmill Exercise. Due to recent advances in Aquatic research, technology, and facilities, many aquatic therapy modes now exist. These Aquatic modes assist individuals (e.g., osteoarthritis patients) in the performance of activities that may be too difficult to complete on land. However, the biomechanical requirements of each Aquatic therapy mode may elicit different physiological and functional responses. Therefore, the purpose of this thesis was to: (a) provide a review of the physiological and biomechanical differences between Aquatic and land-based exercises, and (b) examine the acute effects of underwater and land treadmill exercise on oxygen consumption (VO2), rating of perceived exertion (RPE), perceived pain, mobility, and gait kinematics for patients with osteoarthritis (OA). Methods consisted of retrieving experimental studies examining

the physiological and biomechanical effects of deep water running (DWR), shallow water running (SWR), water calisthenics, and underwater treadmill therapy. The methods also examined the physiological and biomechanical effects on 19 participants during and after three consecutive exercise sessions on an underwater treadmill and a land-based treadmill. Based on the studies reviewed, VO2 values are lower during both DWR and SWR compared to a similar land-based mode. Still, they can be higher during water calisthenics and underwater treadmill exercise. RPE responses during DWR are identical during the max effort, and stride frequency and stride length are lower in all four Aquatic modes than on land. Pain levels are no different between most water calisthenics, and most studies reported improvements in mobility after Aquatic therapy, but no difference between the Aquatic and land-based modes. The OA participants achieved VO2 values that were not different between conditions during moderate intensities but were 37% greater during low-intensity exercise on land than in water ($p = 0.001$). Perceived pain and Time Up & Go scores were 140% and 240% greater, respectively, for land than underwater treadmill exercise ($p = 0.01$). Patients diagnosed with OA may walk on an underwater treadmill at a moderate intensity with less pain and equivalent energy expenditures than walking on a land-based treadmill.

**Zaire, V., et al. (2008)** classified the Effect of Aquatic and Sand Plyometric Training on Physical Performance and Muscular Enzymes in Male Wrestlers. This investigation aimed to compare Aquatic and Sand plyometric training about club wrestlers' performance and muscular injury. For this reason, twenty-one voluntary club wrestlers were randomly selected and divided into two experimental groups (Sand plyometric training, n=7; Aquatic plyometric training, n=7) and a control group (n=7). The mean (SD) of age was 20.3 (3.6); height, 169 (5.3); and weight, 65.3 (8.8).

Experimental groups trained four primary plyometric training skills, including depth, star, rocket, and squat jumps, for forty to forty-five min per session, three times per week for five weeks. Control groups had their routine training. They determined the effects of plyometric training on strength, speed, agility, fatigue index, and peak and mean power. To evaluate the pathogenesis of these training, they measured inflammatory enzymes, including CK and LDH. Data analysis using variance and t-test showed no significant difference between the two models of plyometric training about the performance and risk for muscle injury of male club wrestlers. Aquatic plyometric provided the same performance enhancement benefits as Sand plyometric, with less muscle soreness.

**Barela, A.M., Duarte, M. (2008)** analyzed the Biomechanical characteristics of elderly individuals walking on land and water. In this study, we examined Spatial-temporal gait stride parameters, lower extremity joint angles, ground reaction forces (GRF) components, and electromyographic activation patterns of 10 healthy elderly individuals (70+/-6 years) walking in water and on land and compared them to a reference group of 10 younger adults (29+/-6 years). They all walked at self-selected comfortable speeds both on land and immersed in water at the Xiphoid process level. Concerning the elderly individuals, the main significant differences observed were that they presented shorter stride length, slower speed, lower GRF values, higher horizontal impulses, and smaller knee range of motion, lower ankle dorsiflexion, and more knee flexion at the stride's initial contact in water than on land. Concerning the comparison between elderly individuals and adults, elderly individuals walked significantly slower on land than adults, but both groups presented the same speed walking in water. In water, elderly individuals presented significantly shorter stride length, lower stride duration, and higher stance period duration than younger adults.

That is, elderly individuals' adaptations to walking in water differ from those in the younger age group. This fact should be considered when prescribing rehabilitation or fitness programs for these populations.

**Kilding, A.E., et al. (2007)** ascertained the kinematic comparison of deep water running and overground running in endurance runners. Deepwater running (DWR) is commonly used as a rehabilitative tool or running specific cross-training modality. However, because little is known about this training's biomechanical specificity, this study aimed to compare DWR's leg kinematics vs. overground running (OGR). Five endurance runners' leg actions in the sagittal plane were filmed in 2 dimensions in DWR and OGR at slow (72 cycles. min(-1)) and fast (92 cycles. min(-1)) frequencies to measure hip and knee angles. Hip-knee angle-angle diagrams were quantified using cross-correlations (r). Leg motion was different between DWR and OGR both kinematically (e.g., hip maximum flexion angle, slow frequency: DWR = 92 +/- 20 degrees; OGR = 49 +/- 10 degrees ; $p < 0.05$) and in coordination (e.g., slow frequency: DWR, r = -0.94, lag = -1%; OGR, r = 0.87, lag = 22%). The time lag indicates that the hip and knee flex and extend together in DWR, whereas the hip moves before the knee during OGR. Stride frequency affected OGR but not on DWR. The apparent differences between DWR and OGR are likely to affect muscle recruitment patterns, which could be problematic for athletes with hip and knee injuries. Because DWR's negative effects as a rehabilitative tool are not known, gradual familiarization to DWR before a prescribed DWR rehabilitation or intense fitness maintenance program is recommended to offset any adverse effects.

**Takahashi J, Ishihara K, Aoki JJ Sports Sci. (2006)** described the effect of aqua exercise on the recovery of lower limb muscles after downhill running. The

present study aimed to examine how the recovery of the physiological functioning of the leg muscles after high-intensity eccentric exercise such as downhill running could be promoted by aqua exercise for a period until the damaged muscle had recovered almost completely. Ten male long-distance runners were divided equally into an aqua exercise group and a control group. From the first day (Day 0) to the fourth day (Day 3), the participants completed a questionnaire on muscle soreness, serum creatine kinase activity, muscle power, flexibility, whole-body reaction time, and muscle stiffness were measured. After measurements on Day 0, the participants performed downhill running (three 5 min runs with a 5 min rest interval at -10%, 335.7 +/- 6.1 m. min-1). The aqua exercise group performed walking, jogging, and jumping in the water on three successive days following the downhill running on Day 0 for 30 min each day. Muscle power was reduced on Day 1 in the control group ($P < 0.05$). Muscle soreness in the calf on Day 3 was more significant in the control group than in the aqua exercise group ($P < 0.05$). In the aqua exercise group, muscle stiffness in the calf was less than that in the control group over four days (time main effect: $P < 0.05$; group x time interaction: $P < 0.05$). We conclude that aqua exercise promoted the physiological functioning of the muscles in the legs after high-intensity downhill running for a period until the damaged muscles had recovered almost completely.

**Barela AM., et al. (2006)** emphasized the biomechanical characteristics of adults walking in shallow water and land. Although the water environment has been employed for different physical activities, there is little available information regarding the biomechanical characteristics of walking in shallow water. In the present study, we investigated the kinematics, ground reaction forces (GRF), and electromyographic (EMG) activation patterns of eight selected muscles of adults walking in shallow water and on land. Ten healthy adults were videotaped while

walking at self-selected comfortable speeds on land and water (at the Xiphoid process level). In both conditions, there was a force plate embedded in the middle of each walkway to register the GRF components. Reflective markers were placed over main anatomical landmarks and they were digitalized later to obtain stride characteristics and joint angle information. In general, walking in water was different from walking on land in many aspects. These differences were attributed to the drag force, the apparent bodyweight reduction, and the lower comfortable speed during walking in shallow water. The joint range of motions (ROM) was not different; the segment ROM, magnitudes of GRF components, impact force, and impulse were different between the two conditions. The present results will contribute to a better understanding of this activity in training and rehabilitation.

**Miyoshi T. et al. (2005)** concluded the functional roles of lower-limb joint moments while walking in water. To clarify the functional roles of lower-limb joint moments and their contribution to support and propulsion tasks while walking in water than on land. Sixteen healthy, young subjects walked on land and in the water at several different speeds with and without additional loads. Walking in water is an effective rehabilitation therapy for patients with orthopedic disorders. However, the functional role of lower-limb joint moments while walking in water is still unclear. Kinematics, electromyographic activities in biceps femoris and gluteus maximums, and ground reaction forces were measured under the following conditions: walking on land and in the water at a self-determined pace, slow walking on land, and fast walking in water with or without additional loads (8 kg). Inverse dynamics calculated the hip, knee, and ankle joint moments. The walking speed contribution increased the hip extension moment, and the additional weight increased the ankle plantar flexion and knee extension moment. The significant functional role was different in each

lower-limb joint muscle. The muscle group in the ankle is to support the body against gravity, and that of the muscle group involved in hip extension is to contribute to propulsion. Also, walking in water not only reduced the joint moments but also completely changed the inter-joint coordination. It is of value for clinicians to be aware that the greater the viscosity of water produces, the more significant load on the hip joint when fast walking in water.

**Campbell. et al. (2003)** studied the Metabolic and Cardiovascular Response to Shallow Water Exercise in Young and Older Women. The purpose of this study was to compare the metabolic and cardiovascular responses of young (Y) and older (O) women ages 19-24 yr ($N$ = 11) and 63-72 yr ($N$ = 11), respectively while performing shallow water exercise (SWE). Resting metabolic rate was determined, as was the metabolic (indirect calorimetry) and heart rate (Polar monitor) responses to five submaximal and one maximal SWE bout and a 40-min SWE class. 1) One metabolic equivalent (MET) equaled (mean ± SE) 3.3 ± 0.2 mL O2·min-1·kg-1 (Y) and 2.8 ± 0.1 mL O2·min-1·kg-1(O) ($P < 0.05$); 2) submaximal (bouts 1-5) MET and HR responses ranged from 3.5 to 8.6 and 95 to 144 bpm (Y), and 3.2 to 6.3 and 92 to 124 bpm (O); 3) estimated MET, % HRpeak, and kcal O2 per minute at given relative efforts (% V̇O2peak) were greater for the older group ($P < 0.05$), whereas no difference in RPE was found; 4) peak MET and HR equaled 11.7 ± 0.8 and 182 ± 3 bpm (Y) and 7.6 ± 0.4 and 156 ± 5 bpm (O), respectively ($P < 0.05$); 5) SWE class: overall, estimated average MET level was 4.9 ± 0.3 (O) and 5.8 ± 0.4 (Y) ($P > 0.05$); the overall relative intensity (% METpeak) was greater for the O group (61.5 ± 2.5 vs 48.8 ± 2.2) ($P < 0.05$). SWE elicited metabolic and cardiovascular responses that met ACSM's guidelines for establishing health benefits. Furthermore, older females may

self-select a greater relative exercise intensity during SWE compared with younger counterparts when provided with the same verbal instructions and encouragement.

**Smith, Robert MS., et al. (2002)** found the movement in the Sand and its training implications for Beach Volleyball. The study aimed to assess the effect of Sand training on Beach volleyball players. The participants were twenty-four University Sport club members (men) with a mean age of twenty years. They were randomly assigned to one of the two experimental groups (two treatments and one control). The two treatment groups participated in a Sand training program three times a week for twenty weeks. The changes in physical strength during the term of twenty weeks were examined. The control group participated in the games (beach volleyball). The treatment group participated in both games and the Sand training program. The battery was composed of eight physical and motor tests and two skill tests. The physical and motor tests included two-speed tests, an agility run, four explosive power tests, and an endurance test. The test was conducted before and after the training program. Significant improvements in treatment groups were seen after the twenty weeks training program. A physical explosive power test (vertical jump with approach) was a good indicator for the players.

**Kelly S. Chu., Edward C. Rhodes. (2001)** analyzed the Physiological and Cardiovascular Changes Associated with Deep Water Running in the Young: Possible Implications for the Elderly. The increased number of people taking part in deep water running (DWR) is attributable to this form of exercise's weight-independent characteristic. However, deepwater runners should be aware of the respiratory and cardiovascular repercussions that result from exercising in water. It has been well documented that water immersion (WI) alone results in decreased respiratory and

cardiovascular parameters in young individuals immersed in water to the neck. These decrements become more pronounced with exercise, such that maximal oxygen consumption and heart rate (HR) are lower during DWR compared with running on land. Age also seems to influence these parameters; Derion et al. found little to no change in cardiac output, stroke volume, and HR during WI in older individuals than the decrease experienced in younger individuals. In contrast, gender appears to have no effect on WI or DWR response. Although differences in acute metabolic reactions have been observed in numerous studies, training studies examining the effectiveness of using a DWR training program found that DWR produced equivocal training responses compared to the fit and highly trained individuals running on land. Less convincing evidence has been provided for untrained individuals seeking benefits from a DWR training program, as some studies showed significant improvements while others did not. There is a current lack of knowledge regarding this form of exercise by frail elderly individuals and those with osteoporosis.

## 2.2 STUDIES ON SAND TRAINING

**Vishal, K. (2016)** stated that the impact of sand running on developing endurance among athletes. 30 Male athletes between the age group of 19 to 24 years (15 Experimental Group and 15 Control Group) were taken for the study. The Six Weeks endurance training program for the experimental group included more sand running on alternate days, and the controlled group was assigned general training of athletics. The Pre Test and Post Test were conducted through the Cooper Test for both groups to evaluate the impact of sand running. This study shows that sand running has increased the endurance among the Experimental Group along with the Physiological capacity of the athletes. It is recommended that sand running is good for the endurance development of athletes.

**Asadi, A. (2015)** distinguished the Muscular performance adaptations to short-term plyometric training on the sand. The current investigation aimed to determine the effects of short-term plyometric depth jump training on sand interposed with 48 hours or 72 hours of rest between training sessions on power type muscular adaptations in recreationally physically active men. Fifteen collegiate physically active men familiar with the plyometric exercise participated in this study and were randomly divided into plyometric training with 48 h (PT48, N=7) and 72 h (PT72, N=8) of rest between training sessions. Pre and post-training on the sand, participants were measured in the vertical jump (VJ), standing long jump (SLJ), agility t-Test (TT), 20 and 40 m sprints, and one-repetition maximum leg press (1RMLP). The plyometric training program on the sand was applied for six weeks, two sessions per week, with five sets of 20 repetitions depth jump exercises from 45 cm box height. After completing six weeks of training, the PT48 and PT72 groups showed significant improvement in all performance tests with statistically significant differences between TT and 40 m sprint time treatments. About significant differences in TT and 40 m sprint for PT72 compared with PT48 and more significant improvements for PT72 in all tests, it can be recommended that coaches, strength and conditioning professionals applied 72 h rest between plyometric training sessions when sand surface was used.

**Binnie, M. J. (2013)** conclude the effect of surface-specific training on 20m sprint performance on sand and grass surfaces. Twelve team sport athletes have attended one-hour training of three sessions per week, including two surface-specific sessions (Sand; six subjects, grass; six subjects) and one group session conducted on the grass. Throughout the training period of eight weeks, all athletes' 20m sprint times were recorded on both sand and grass surfaces at the end of weeks one, four, and eight. Results showed a significant improvement in 20m sand time in the sand group

only ($p<0.05$), whereas 20m grass time improved equally in both training groups ($p<0.05$). The study was concluded that surface-specificity was essential for 20m speed improvements on the sand. Also, there was no detriment to grass speed gains when incorporating sand surfaces into a pre-season program.

**Pradeep, C.S. (2013)** ascertained the effect of sand running on endurance development among athletes. To achieve this purpose, 40 male athletes aged between 18 and 25 were selected from Kerala University. They were divided into two equal groups, namely the experimental group and the control group. A pre-test was conducted on cardiorespiratory endurance by using 12 minutes of Cooper's run\walk test. The experimental group underwent eight weeks of sand running training on alternative days, and the control group underwent only the regular general physical activities training of athletics. After eight weeks of training, the post-test was conducted. Analysis of covariance (ANCOVA) statistical technique was used to test the significant differences among the groups. The study was conducted that sand running was significantly improved the endurance among college men athletes.

**Sharma, Rajkumar (2013)** conducted a study to determine the effect of sand training on junior volleyball players' jumping abilities. For this purpose, 30 volleyball players aged between 16 and 19 years from S.A.I. training center, Rajnandgaon, Chhattisgarh was selected, and they were divided into two equal groups of 15 subjects each. Groups-A underwent six weeks of sand training, and Group-B acted as the control group. The Control group only practiced the technical and tactical skills of volleyball. Pre and post-tests were conducted on selected dependent variables such as block jump (BJ), Spike Jump (SJ), and standing broad jump (SBJ) before and immediately after the training, respectively. Mean, Standard Deviation, and 't' test was

used as statistical techniques, and significance was set at 0.05 level of confidence. The study was concluded that six weeks of sand training would significantly improve on vertical block jump, spike jump, and standing broad jump among junior volleyball players.

**Gortsila, Eugenia (2013)** described the effect of training surface on agility and passing skills of prepubescent female volleyball players. To achieve this purpose, 45 prepubescent girls aged between 11 and 12 years were selected at random, and they were divided into three equal groups, namely Group S, Group I, and Group C of 15 subjects each. Group S and I consisted of volleyball players, and Group C (control group) consisted of girls with no volleyball training experience. All three groups participated in a 10weeks (three days/a weeks) volleyball training program that included technical and passing skill exercises. Along with this training, Group S underwent special training included jumping and sprinting exercises on the sand surface; Group I experienced the same training on a hard surface, and Group C had no special training. Pre-tests were conducted on agility and passing skills for all three groups. After ten weeks of training, post-tests were conducted. Pre and post-tests data were statistically analyzed by using two-way ANOVA. The study was concluded that the sand training groups (Group S) significantly improved agility and passing skills than other groups. Training on the sand surface might be a useful and effective method for improving agility and passing skills in prepubescent female volleyball players.

**Karver, Alical Anne (2012)** proposed sand jump training versus ground jump training for volleyball players. For this purpose, 21 volleyball players aged between 14 and 18 were selected from the Northern California Volleyball Club (NCVC),

Rocklin, California. The subjects were randomly assigned into two groups, namely the sand training group and the ground training group. The sand training group underwent six weeks (two-session/a week) training of various jumping exercises on a sand court along with a grass surface. The ground training group underwent the same training on the ground surface. Pre-test and post-test were taken on the vertical jump before and immediately after the six weeks of training. A two-tailed independent t-test was used to compare the groups' differences, and a two-tailed paired t-test was used to compare the group differences. The study was concluded that six weeks of jump training programs significantly improved the vertical jump of participants in both sand and ground training groups, and there were no significant differences between the groups.

**Alcaraz, P.E., et al. (2011)** reported the effects of sand running surface on sprinting kinematics at maximum velocity. This study aimed to compare the kinematics of sprinting at maximum velocity on a dry sand surface to the kinematics of sprinting on an athletics track. To achieve this purpose, five men and five women athletes participated as subjects, and they underwent 30m flying sprints on different surfaces such as synthetic athletics track and beach sand surface. All the sprints were recorded using a video camera, and biomechanical analysis software was used to analyze the video images at the trails. The study revealed that sprinting on a sand surface was substantially different from sprinting on an athletics track. A lower center of mass characterized this action; a greater forward lean in the trunk, and an incomplete extension of the hip joint at take-off. The study was concluded that sprinting on a dry sand surface may not be an appropriate method for training the maximum velocity phase in sprinting. Although this training method exerts a substantial overload on the athlete, as indicated by reductions in running velocity and

stride length, it also induced detrimental changes to the athlete's running technique, which may transfer to competition sprinting.

**Sathishkumar, S. (2011)** examined the effect of sand and offshore training on selected physical and physiological variables among inter engineering college-level football players. To achieve the study's purpose, 45 engineering college football players were selected, and they were divided into three groups of 15 subjects each. Experimental Group- I was assigned as a sand training group, experimental group II assigned as an offshore training group, and Group III assigned as a control group. Pre-tests were conducted on selected physical fitness and physiological variables such as speed, agility, endurance, resting pulse rate, breath-holding time, and blood pressure. After six weeks of sand and offshore training to the respective experimental groups, post-tests were conducted. Analysis of covariance (ANCOVA) and Scheffe's post-hoc test was used to test the significant mean differences among the experimental groups. The study was concluded that six weeks of sand training significantly improved the selected dependent variables such as speed, agility, endurance, resting pulse rate, breath-holding time, and blood pressure than offshore training among inter engineering college football players.

**Jacob S. (2010)** emphasized the effect of sand training and seashore training on selected physical fitness variables such as speed, endurance, power, flexibility, cardiovascular endurance, agility, and performance variables among school level volleyball players. For this purpose, 30 school level volleyball players were selected from different schools in Chennai, and they were randomly divided into three groups. Pre-tests were conducted for all three groups. Group I participated in sand training exercises, Group II participated in seashore training, and Group III acted as a control

group. Post-tests were conducted after six weeks of sand and seashore training. Analysis of covariance (ANCOVA) and Scheffe's post-hoc tests were used as statistical techniques. The study was concluded that significant improvement in speed, endurance, agility, and flexibility due to the influence of six weeks of sand and seashore training. It was also supposed that there was no significant improvement in volleyball playing ability due to six weeks of sand and seashore training.

**Kondapalli, Sreenivasa Rao (2010)** analyzed the effect of sand running on speed and cardiorespiratory endurance of male university students. To achieve this purpose, 30 male students studying in the Department of Physical Education and Sports Sciences, Acharya Nagarjuna University, Nagarjuna Nagar, Andhra Pradesh, India, were selected as subjects random. The age of the subjects ranged from 18 to 24 years. The selected subjects were divided into two equal groups of 15 subjects, such as sand running and control groups. Group I underwent a sand running program for three days/ a week for 12 weeks. Group II acted as a control group and did not participate in any special training program apart from their regular physical education activities. All the subjects were tested on selected criterion variables such as speed and cardiorespiratory endurance before and immediately after the training program using the 50m run and Cooper's 12 min run/walk test. The Analysis of Covariance (ANCOVA) statistical technique was used to test the significant mean differences among the groups. The level of significance was fixed at 0.05 level. The study results revealed that sand running groups showed significant improvement in speed and cardiorespiratory endurance than the control group.

**Visnes H (April 2010)** distinguished the effects of training on different Surfaces. This study aimed to compare the impact of training on different surfaces

like grass, sand, and road. Hundred professional athletes who took part in this study were selected as subjects by random sampling method and divided into four equal groups of twenty-five athletes in each group were assigned training on grass, road, and sand. The fourth group served as a control group. To analyze the differences in the twelve min run and walk test performance t and vertical jump test of three experimental and control groups. Before the training on different surfaces, the performances of twelve min run and walk test and vertical jump and calf and thigh circumference of each athlete are measured as pre-test results. Eight weeks of a training program on different surfaces is conducted to all the three groups simultaneously, and no training was given to the control group. After the training, each athlete's calf and thigh circumference are measured as post-test results; a further vertical jump test is administered. There was a significant effect of training on different surfaces on the performances of three groups. There was a significant effect of training on sand compared to the other two groups. Calf and thigh circumference increased significantly on the Sand surface. Both treatment groups showed a similar significant increase in the vertical jump. The twelve-min run/walk was increased considerably in Sand runners. They concluded a significant effect of eight weeks of training on the sand, resulting in the most physical, physiological, and performance changes.

**Karve, R., and Tiwari, P.S. (2010)** found that running training on different Surfaces has different effects on performance. One twenty college athletes from different colleges of Gulbarga District were selected as subjects by random sampling method and divided into four equal groups of thirty athletes in each Group: Experimental Group I running training on Sand, Experimental Group II running training on red mud track, Experimental Group III running training on a cinder track

and Group IV served as a control group. Before the training on different running surfaces, the performances of twelve min run and walk test and vertical jump and calf and thigh circumference of each athlete were measured as pre-test results. Eight weeks of a training program on different surfaces was conducted for all three groups simultaneously, and no training was given to the control group. After the training, each athlete's calf and thigh circumference was measured as post-test results; a further vertical jump test was administered, and Cooper's twelve min run and walk test was conducted on the cinder track. They concluded that there was a significant effect of running training on different surfaces on three groups' performances. There was a significant effect of running training on different surfaces on the performance of group I (running training on sand) as compared to the other two groups. Calf and thigh circumference increased significantly in Sand runners. Both treatment groups showed a similar significant increase in the vertical jump. The twelve-minute run/walk had significantly increased in Sand runners.

**Kevin T, Duncanand Hayes (2009)** studied the Effect of Two Plyometric Dry Sand Training Techniques on Muscular Power and Agility in Youth Soccer Players. This study aimed to compare the effects of two plyometric dry Sand training techniques on power and agility in youth soccer players. Twelve males from a semi-professional football club's academy (age = 17.3 ± 0.4 years, stature = 177.9 ± 5.1 cm, mass = 68.7 ± 5.6 kg) were randomly assigned to six weeks of training twice weekly. Participants in the DJ group performed drop jumps with instructions to minimize ground-contact time while maximizing height. Participants in the CMJ group performed jumps from a standing start position with instructions to gain maximum jump height. Post-training, both groups experienced improvements in vertical jump height ($p< 0.05$) and agility time ($p< 0.05$) and no change in sprint performance ($p>$

0.05). There were no differences between the treatment groups ($p$> 0.05). The study concludes that both DJ and CMJ plyometrics are worthwhile training activities for improving power and agility in youth soccer players.

**Gonzalez-Badillo and Juan (2008)** distinguished the Low and Moderate Beach Sand Plyometric Training Frequency Produces Greater Jumping and Sprinting Gains Compared with High Frequency. The purpose of this study was to examine the effect of three different plyometric training frequencies in Beach Sand(e.g., one day per week, two days per week, four days per week) associated with three different plyometric training volumes on maximal strength, vertical jump performance, and sprinting ability. Forty-two students were randomly assigned to one of the four groups: control ($n$ = 10, 7 sessions of drop jump (DJ) training, one day per week, 420 DJs), fourteen sessions of DJ training ($n$ = 12, two days per week, 840 DJs), and twenty-eight sessions of DJ training ($n$ = 9, four days per week, 1680 DJs). The training protocols included DJ from three different heights twenty, forty, and sixty cm. Maximal strength (one repetition maximum [1RM] and maximal isometric strength), vertical height in countermovement jumps and DJs, and twenty-meter sprint time tests were carried out before and after seven weeks of plyometric training. No significant differences were observed among the groups in pre-training in any of the variables tested. No significant changes were observed in the control group in any of the variables tested at any point. Short-term plyometric training using moderate training frequency and volume of jumps (two days per week, 840 jumps) produces similar enhancements in jumping performance but greater training efficiency (∼12% and 0.014% per jump) compared with high jumping (four days per week, 1680 jumps) training frequency (∼18% and 0.011% per jump). Also, similar enhancements in twenty meters sprint time, jumping contact times, and maximal strength were

observed in both a moderate and low number of training sessions per week compared with high training frequencies, even though the average number of jumps accomplished in 7S (420 jumps) and 14S (840 jumps) was 25 and fifty percent of that performed in 28S (1680 jumps). These observations may have considerable practical relevance for the optimal design of Beach Sand plyometric training programs for athletes, given that a moderate volume is more efficient than a higher plyometric training volume.

**Impellizzeri, F. M., et al. (2008)** conducted a study to determine plyometric training on sand versus grass on muscle soreness, vertical jump height, and sprinting ability in soccer players. For this purpose, 37 soccer players were selected at random. They were divided into two groups, namely the grass group and the sand group. Pre-tests were conducted on 10m, 20m sprint time, squat jump (SJ), countermovement jump (CMJ), and eccentric utilization ratio (CMJ/SJ). Muscle soreness was measured by using a Likert scale. Group I (n=18) underwent four weeks of plyometric training on grass, and group II (n=19) underwent four weeks of plyometric training on the sand. After four weeks of plyometric training, post-tests were conducted for both groups on the above said dependent variables. The results showed that no training surface with time interactions was found for sprint time ($p>0.87$), and both groups showed improvements on the squat jump (SJ) ($p= 0.08$). On the other hand, the grass group improved their countermovement jump (CMJ) ($P=0.033$) and CMJ/SJ ($P=0.005$) more than players in the sand group. In contrast, players in the sand group experienced less muscle soreness than those in the grass group ($p<0.001$). The study was concluded that plyometric training on sand improved both jumping and sprinting ability and induced less muscle soreness. A grass surface seems to be superior in

enhancing countermovement jump (CMJ) performance, while the sand surface showed a more significant improvement in the squat jump.

**Pandey, Sarika (2008)** made a study to find out the comparative effect of training on different playing surfaces on selected physical, physiological and anthropometric variables, namely explosive strength, speed, agility, cardiovascular endurance, resting pulse rate, blood pressure, vital capacity, respiratory rate, weight, height, calf circumference and thigh girth among female players. Achieve the study's purpose, 100 female players were selected from different schools of BHEL, Haridwar, and their age was between 14 and 16 years. They were divided into five groups. Group A underwent training on a grassy surface; Group B underwent training on a non-grassy surface. Group C underwent training on a wooden surface; Group D underwent training on a sand surface, Group E was assigned as a control group. Pre-tests were conducted on physical, physiological, and anthropometric variables such as explosive strength, speed, agility, cardiovascular endurance, resting pulse rate, blood pressure, vital capacity, respiratory rate, weight, height, calf, and thigh girth. After ten weeks of training for the respective groups, post-tests were conducted. The covariance and LSD test (post-hoc test) test the significant mean differences among the groups. The study concluded that ten weeks of training on sand surface significantly improved the selected dependent variables, namely explosive strength, speed, agility, cardiovascular endurance, resting pulse rate, and weight reduction than the other groups among female players.

**Francis Xavier (2002)** examined the comparative effects of training on dry sand and wet sand on physical and physiological variables such as speed, explosive power, endurance, agility, pulse rate, blood pressure, vital capacity, and respiratory

rate of female soccer players. For this purpose, 90 girls' football players from different schools were selected randomly from the age group of 14 to 16 years. They were divided into three equal groups of 30 subjects each. Group A underwent wet sand training, Group B underwent dry sand training, and Group C acted as a control group. Pre-tests were conducted on selected dependent variables before the commencement of training. After ten weeks of training five days a week, post-tests were conducted on selected dependent variables. The Analysis of covariance (ANCOVA) statistical technique was applied for this study. The study was concluded that the wet sand group performance on speed and pulse rate was best among the three groups. The wet sand group and the dry sand group were showed better results on explosive strength and endurance than the control group. There was no change in blood pressure, vital capacity, and respiratory rate among all the three groups.

**Dowzer CN, Reilly T, and Cable NT (1998)** showed research titled "Comparison of the Endurance Training Responses to Road and Sand Running in University Male Students" Sand training was compared to the same intensities of road training for eight weeks. Active college and high school students (N = 54) were assigned to three groups: Sand training, road training, or control. Training sessions were for thirty minutes, three times per week. Both training groups increased thigh circumference, vertical jump scores, and time for a twelve-minute walk/run test. The Control group did not change in any measures. The Sand group alone improved calf circumference. Both forms of training improved performance and structure, but the more demanding Sand running exercises impacted the leg's shank to a greater degree. They concluded that sand and road are running improved fitness and performance for the active but not explicitly trained young people. However, they added that it should not be assumed that similar effects would be obtained with specialized runners.

**Semih, Yigit, and Tuncel (1998)** directed research titled "A Comparison of the Endurance Training Responses to Road and Sand Running in High School and College Students."This study compared the physical and physiological alterations that occurred in male high school and college students due to a six-week endurance-training program. Fifty-one students, aged fifteen to twenty one, were assigned to one of the three groups: road (n = 14), Sand (n = 19), or control group (n = 18). The twelve-min run/ walk test, vertical jump (VJ), and thigh and calf circumference were measured pre-and post-training. One-way ANOVA, paired *t*-test, and Tukey test were used to evaluate the effects of training. Sand runners and roadrunners had a similar significant ($p < 0.05$) increase in thigh circumference. Calf circumference increased significantly in Sand runners. Both treatment groups showed a similar significant increase in the vertical jump. The twelve-min run/walk distance significantly improved in Sand runners. This study showed that a six-week Sand running program might improve physiological and performance changes in young men.

## 2.3 STUDIES ON BIO-MOTOR VARIABLES

**Ramajayam, M. (2018)** suggested the impact of cross-training and specific drills on the bio-motor and skill performance variables of badminton players. Badminton players of the age group 22 to 25 years were selected for the study. The group was divided into two parts, one who will take part in drill and training for five days a week for three months, and the other will group will not participate in training. Under bio-meter variables, 50 meters running, flexibility test, and skill performance tests were done for the experimental group. The pre-test and post-test data were collected, and analysis was done with covariance "ANCOVA." 0.05 was the confidence level that was fixed. The outcome of the study indicates that there was a considerable betterment in the bio-meter variables "speed and flexibility" and skill

variables "short service and long service" by undergoing the cross-trainings and various other plyometric training methods for 12 weeks as compared to the group that did not participate in any training.

**Singh, R. (2018)** identified the correlation between selected motor fitness variables and football players' playing ability. To achieve the purpose, 150 men football players were randomly selected as subjects from the Tamil Nadu State level men Football tournament held at Chennai in the year 2008-2009, and their age was between 20 and 25 years. They were divided into three groups of 50 subjects in each Group and Group I served as the Chennai team, group II served as Salem and Coimbatore team, and Group III serves as Trichy and Madurai team. All the subjects have oriented the purpose and procedure of conducting this test. Regular activities and training were given aplomb to the player's ability to perform the game. Data was collected through a questionnaire, and tests were conducted on selected motor fitness components such as cardiovascular endurance, speed, agility, and explosive power before and after the competition. The collected data were statistically analyzed using ANOVA, and the group means were compared using Duncan's Multiple Range Test (DMRT). The study was concluded that playing ability mainly depends on the physical fitness components and stress-free mind among state-level football players.

**Ozmen, T., Aydogmus, M. (2017)** studied the effect of coordination and plyometric exercises on agility, jumping, and endurance ability in badminton players. The most important motor skills in the badminton game to hit a shuttlecock are agility and vertical jump. Two groups were created with twenty badminton players in total; the two groups were "Plyometric group (PG)" and "Control group (CG)." A pre-test was conducted, where all the participants were tested to check agility and vertical

jump, and later another test was conducted once the training was completed. Illinois Agility Test was applied to check the agility performance of the players. The agility impressively improved in the "PG" group but not in the "CG" group. Hence, as per the study, the plyometric training of six weeks, which the PG group did, improved their agility and vertical jump.

**Aktas, S., Guven, F., &Er, Y. (2017).** This study aimed to determine some physical parameters of badminton players between the ages of 10-12. Fifteen badminton players 10-12 years old volunteered to participate. The players continued their badminton training for eight weeks. After the eight weeks of training, their 15 m speed, vertical jump, standing broad jump, handgrip strength, and flexibility tests were conducted. To analyses the data, a paired t-test was used to compare the pre-and post-test tests. After the eight weeks' badminton training, subjects' vertical jump, handgrip strength (right hand), and flexibility performances increased significantly (p0.05). As a result, it can be said that the badminton training of an 8-week might improve vertical jump, flexibility, and handgrip strength in 10-12 years old badminton players. However, the training may not affect their 15 m speed and standing broad jump performance.

**Jiun Yang Low, Kai Quin Chan, Hui Yin Ler (2016)** Multi-shuttle training was very popular and specific for the badminton training session. The badminton multi-shuttle feeding form possessed the quality of High-Intensity Intermittent Training (HIIT), which resulted in physiological adaptations and improvement in physical performance. However, its effectiveness has not been extensively examined in Badminton. This study examined the effects of high-intensity intermittent badminton multi-shuttle (HIIBMS) feeding training on aerobic and anaerobic

capacity, leg strength qualities, and agility. Eighteen university college badminton players (AGE = 20 ± 1 year, BW = 65.3 ± 11 kg; H = 173.0 ± 5.3 cm) were recruited into this study. The subjects were pre-tested on aerobic capacity, reactive leg strength, and agility parameters. Subsequently, they were randomly selected and assigned into two groups (control group [CG], experimental Group [EG]). Both groups had similar badminton training, while additional HIIBMS feeding training was given to the EG for four weeks. The two groups started equally as the pre-test for the six research variables revealed insignificant results. The post-test results were also insignificant for all six variables. However, pre-test and post-test mean scores comparisons showed significant improvements in VO2max, mean power, reactive leg strength, and agility except for peak power and jump height in EG. CG showed no improvement in all parameters. Further research with a longer intervention duration should be conducted to solicit more information.

**Karatnyk I.V., HrechanyukO.O., et al. (2016)** examined the Perfection of badminton players' speed-power fitness with the help of training means' variable modules. Badminton players of 15 to 17 years of age participated in the training program. The players were divided into three groups. The program was for six months, with distinct variants. A separate exercise complex is contained in three modules: each module has three parts – "Speed, Power, and Jumping." All the programs were constituted in a program of speed power fitness perfection of badminton players. Towards each experimental group, a different variant of the module was used: First variant – "1-2-3 module," Second variant – "2-3-1 module" and Third variant – 3-2-1 module." The usual time of the program was six months micro-cycles. At the start and end of each module, the Control measurement of speed-power fitness was satisfied. As an outcome of this variant's understanding, it is found

that there is no positive difference in the three control exercises. The outcome allows suggesting some variants of variable modules blending as the training procedure's solution has planned activities oriented to the excellence of the "speed-power fitness" of badminton players.

**Mehmet Fatih Yuksel. et al. (2015)** training program on some fitness parameters of beginner-level badminton players. After two months of training, it was determined that the vertical jump increased for the experimental group (t = -5.467). It was determined that the standing broad jump performance showed a significant improvement in performance for the experimental group (t = -5.045). Interestingly, the control group's vertical jump (t = -2.091) and standing broad jumping jump (t = -2.214) values were found to increase significantly after eight weeks. The total balance scores in the experimental group significantly decreased on a firm surface (t = 6.048), foam surface (t = 6.7621), (t = 8.505) after the training. The total BESS (t = -1.437) scores statistically did not significantly differ after the training. The result of this study could be of help to coaches and athletes to improve performance through the selection and adjusting to a suitable training program.

**Trzaskoma, L. et al. (2010)** conducted a study to determine the effect of a short- term combined conditioning training to develop leg strength and power. The study aimed to compare combined weight and pendulum training exercises with those isolated ones on muscle strength and vertical jump performance. 38 active young men were divided into four groups performing different combinations of strength and power training and measured directly and two weeks after the training program. Weight training and pendulum swing exercises involving the lower body during dynamic bounces were used. One repetition maximum (1RM) in a full squat and squat

jump with the barbell, maximal force measured during a countermovement jump (CMJ), and hip and knee flexor and extensor isometric strength were analyzed. Significant differences (p<or= 0.05) in strength test (1RM squat, hip, and knee flexor, and extensor strength) were found when performing weight training (1RM-10.2%; maximal torques-23.2%). A significant positive increase (p <or= 0.05) in all strength and power parameters such as maximal torques, One RM squat, CMJ power, CMJ height after the training program was found when combined training was used. Seated safety position during the pendulum swing was responsible for significant training effects with reduced loads. Plyometric pendulum swing training combined with traditional training can be an alternative, effective method to increase muscle strength and power during short pre or in-season mesocycles.

**Ahmed, K, Kwong., et al. (2009)** studied the "physical and physiological" characteristics of "elite" and "sub-elite" badminton performers along with; this researcher also tried to identify if these characteristics distinguish "elite" performers from "sub-elite" performers. Players were selected and divided into two groups. Tests conducted of basic anthropometry, explosive power, the capacity of anaerobic capacity, agility movement of Badminton, maximum strength, and aerobics capacity on alternate days. In contrast to the "sub-elite" players, the "elite players" showed higher absolute strength in the repetition maximum bench presses. Considerable dissimilarity identified in instant lower body power evaluated from vertical jump height among elite and sub-elite players. However, in shuttle run tests agility movement specific to on-court Badminton, no remarkable difference was identified between the groups. Elite players are tall, heavy body, and strong in contrast to "sub-elite" players. The battery test does not permit us to distinguish between elite and sub-elite players, recommending that tactical knowledge at an elite level, technical skills,

and psychological fitness is significant. The dissimilarity in strength "upper and lower limb" was not clear when stabilized to body mass.

**Chtara, M. et al. (2008)** analyzed the effect of concurrent endurance and circuit resistance training sequences on muscular strength and power development. The purpose of this study was to examine the influence of the sequence order of high-intensity endurance training and circuit training on changes in muscular strength and anaerobic power. Forty-eight physical education students aged between 20 and 23years were assigned as subjects, and they were divided into five groups. The first group underwent endurance training (E, n=10), the second group underwent circuit training (S, n=9), the third group underwent endurance before circuit training in the same session( E+S, n=10), the fourth group underwent circuit before endurance training in the same session (S+E, n=10) and the fifth group acted as the control group (C, n =9). Training consisted of two sessions per week for 12 weeks. Resistance type circuit training targeted strength endurance (Weeks one to six) and explosive strength and power (weeks 7 to 12). Endurance training sessions included five repetitions run at the velocity associated with VO2 Max. A duration equal to 50 % of the time to exhaustion at VO2 Max; recovery was for an equal period at 60 % VO2 Max. The study was concluded that 12 weeks of concurrent endurance and circuit resistance training sequences significantly improved muscular strength and anaerobic power.

## 2.4 STUDIES ON PHYSIOLOGICAL VARIABLES

**Sharma, Hari Om (2013)** studied the effect of stair climbing and sand running on selected physiological variables among football players. To achieve the study's purpose, 30 football players from different colleges of Chennai were randomly selected, and their age was between 18 and 23 years. They were divided into three

groups of 10 players in each group. Group, I underwent stair climbing training, group II underwent sand running for six weeks, and Group III was assigned as the control group. Pre-tests were conducted on selected physiological variables, namely vital capacity, and tidal volume. Post-tests were conducted after six weeks of training. Analysis of covariance (ANCOVA) and Scheffe's post-hoc test was used to test the significant mean differences among the experimental groups. The study concluded that six weeks of stair climbing significantly improved the selected dependent variables, namely vital capacity, tidal volume, and sand running among football players. Jacob, S. (2013) conducted a study to determine the effect of selected drill practice and aerobic exercises on VO2 Max and Hemoglobin among college men football players.

To achieve the study's purpose, 45 football players from different colleges of Chennai were randomly selected, and their age was between 18 and 21 years. They were divided into three groups of 15 subjects each. Group, I was assigned as an experimental group I, Group II assigned as experimental group II and Group III assigned as a control group. Experimental Group I underwent drill practices, experimental group II underwent aerobic exercises for six weeks, and the control group was not assigned to any experimental training. Pre-tests and post-tests were conducted before and after six weeks of training on selected dependent variables, namely VO2 Max and hemoglobin. Analysis of covariance and Scheffe's post-hoc test were used to test the significant mean differences among the experimental groups. The study was concluded that six weeks of selected drill practice and aerobic exercises significantly improved the selected dependent variables, namely VO2 Max and hemoglobin among college men football players.

**Manna, Indranil, et al. (2013)** found the effect of training on morphological, physiological, and biochemical variables of under 23 years soccer players. To achieve this purpose, 30 Indian male soccer players aged below 23 years were selected as subjects. The training sessions were divided into two phases, namely the preparatory phase (PP, eight weeks) and the competitive phase (CP, four weeks). After taking the baseline data at (BD) at zero levels (pre-tests) on selected morphological, physiological, and biochemical variables such as stature, body mass, lean body mass, grip and back strength, VO2 Max, anaerobic power, maximal heart rate, present body fat, urea, uric acid, hemoglobin, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol and triglyceride. After that, the players underwent a training program consisted of aerobic, anaerobic, and skill development training. Post-tests were conducted for all the subjects on the selected morphological, physiological, and biochemical variables immediately after preparatory and competitive phases. The study was concluded that a significant increase ($P<0.05$) in VO2 Max, anaerobic power, grip and back strength, urea, uric acid levels, and a decrease ($P<0.05$) in present body fat, hemoglobin, total cholesterol, and triglyceride levels due to the training. However, no significant change was found in stature, body mass, lean body mass, maximal heart rate, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) among under 23 years soccer players.

**Kumar, Dharmendra, and Sakthignanvel, D. (2013)** have examined the four-week effect of aerobic exercise on obese college males. The research showed that the effect of regular exercise on health and well-being was gained done by regular aerobic exercises. In this study, ten subjects were taken, and their ages range from 18 to 25 years. The aerobic exercise training is given as per scheduled

(45minutes, five days/week for four weeks), and data collected before and after the training program. The results indicated that the vital capacity and body mass index have significantly gained, the aerobic exercise training more effective for the participants. The researcher considered aerobic exercise easy, safe, and also interesting. It has motivated the subjects.

**Sunder, K. (2011)** has reported the isolated and combined effect of aerobic and anaerobic training on selected physical, physiological, and performance variables of college men boxers. To achieve this purpose, 80 college men boxers aged between 18 and 25 were randomly selected from various Tamil Nadu colleges. They were divided into four equal groups of 20 subjects each. Experimental Group I was exposed to aerobic training, Experimental group II was exposed to anaerobic training, Experimental Group III was exposed to combined aerobic and anaerobic training, and the control group was not exposed to any experimental training other than their regular daily activities. The duration of the experimental period was 12 weeks. Pre and post-tests were conducted before and after the 12weeks of training for all the subjects on selected physical variables such as speed, agility, muscular endurance, and explosive arm power and physiological variables such as resting heart rate, breath-holding time, vital capacity, and cardiovascular endurance and performance variables such as punches, defensive skills, and overall boxing ability. Analysis of the Covariance (ANCOVA) statistical technique was administered to determine the significance among the mean differences. If the adjusted post-test results were significant, Scheffe's post-hoc test was used. The study results revealed that 12 weeks of isolated and combined aerobic and anaerobic training would significantly improve the selected physical, physiological, and performance variables of college men boxers.

**Thiyagachanthan, N.V. (2010)** concluded a study to determine the isolated and combined effects of yogic practices and physical exercises on selected physical, physiological and anthropometric variables among college men football players. To achieve the study's purpose, 120 men football players from different colleges of Vellore District, Tamil Nadu, were randomly selected, and their age was between 18 and 25 years. They were divided into four groups: isolated yogic group, isolated physical exercise group, combined yogic and physical exercise group, and control group. Pre-tests were conducted on selected physical, physiological and anthropometric variables such as speed, explosive leg power, agility, resting pulse rate, blood hemoglobin, anaerobic power, chest girth, thigh girth, and calf girth. Post-tests were conducted after 12 weeks of training. Analysis of covariance (ANCOVA) and Scheffe's post-hoc test was used to test the significant mean differences among the experimental groups. The study was concluded that the 12 weeks of isolated and combined effects of yogic practices and physical exercises significantly improved the selected dependent variables among college men football players.

**Brown, G. A., et al. (2010)** made a study on oxygen consumption, heart rate, and blood lactate responses to an acute bout of plyometric depth jump in college-aged men and women. The purpose of this study was to investigate the oxygen consumption, heart rate, and blood lactate responses to a single session of plyometric depth jump. Twenty recreationally trained college-aged subjects (10 men, ten women) participated in a single session of eight sets of 10 box depth jumps from a height of 0.8 m with three minutes of passive recovery between each set. Plyometric depth jumping elicited 82.5 +/- 3.1% and 77.8 +/- 3.1% of the measured maximal oxygen consumption (O2 Max) for women and men, respectively, with no difference in oxygen consumption in ml/kg/min or percent O2 Max between sexes or sets. Heart

rate significantly increased ($p < 0.05$) from 68.1 +/2.9 beats/min at rest to 169.6 +/-1.2 beats/min during depth jumping. Sets five to eight elicited a higher ($p < 0.05$) heart rate (173.3 +/- 1.3 beats/min) than sets one to four (164.6 +/- 1.8 beats/min). Women exhibited a higher heart rate ($p < 0.05$) during sets one and two (169.9 +/- 2.8 beats/min) than men (150.7 +/- 4.4 beats/min). The blood lactate concentrations were significantly ($p < 0.05$) increased above resting throughout all sets (1.0 +/- 0.2 mmol/L compared with 2.9 +/- 0.1 mmol/L), with no differences between sexes or sets. The study was concluded that plyometric depth jumping significantly increased oxygen consumption, heart rate, and blood lactate in both men and women. Still, no significant difference was found between the sexes.

**Chatra, et al. (2005)** documented the effects of intra-session concurrent endurance and strength training sequence on aerobic performance and capacity. To achieve this purpose, 48 male sports students aged between 20 and 23 were selected as subjects, and they were divided into five homogeneous groups according to their maximal aerobic speeds (VO2 Max). Group I ( E, n=10) underwent running endurance training, group II (S, n=9) underwent strength circuit training, Group III underwent(E+S, n = 10) combined running endurance and strength circuit training, group IV (S+E, n=10) underwent combined strength circuit and running endurance training in a different order for 12 weeks, and group V(C, n= nine) served as a control group. All the subjects were evaluated before (T0) and after (T1) the training period using four tests such as a four km time trial running test, an incremental track test to estimate VO2 max, a time to exhaustion test (at 100% VO2 Max and a maximal cycling laboratory test to assess VO2 Max. Training produced significant improvements in performance and aerobic capacity in the four km time trial with interaction effect ($p<0.001$). The study was concluded that circuit training

immediately after individualized endurance training in the same session (E+S) produced greater improvement in the four km time trial and aerobic capacity than the other groups.

**Caputo, F. et al. (2004)** analyzed the effects of aerobic endurance training status and specificity on oxygen uptake kinetics during maximal exercise. The main purpose of this study was to analyze the effects of exercise mode, training status, and specificity on the oxygen uptake (VO2) kinetics during maximal exercise performed in treadmill running and cycle ergometry. Seven runners (R), nine cyclists (C), nine triathletes (T), and 11 untrained subjects (U) performed the tests on different days on a motorized treadmill and a cycle ergometer. The U group showed the lowest values for V02 Max, regardless of exercise mode. Differences in the effective time constant of the VO2 response ( tau VO2, in seconds) were found only for the U group about the trained groups; no exercise mode effects were found in any of the groups. It was concluded that tau VO2 during the exercise performed at VO2 Max was dependent on the training status but not dependent on the exercise mode and specificity of training. Moreover, the transfer of the training effects on tau VO2 between both exercise modes may be higher compared with VO2 Max.

**Millet, G. P., et al. (2002)** studied the effects of concurrent endurance and strength training on running economy and VO(2) kinetics. The purpose of this study was to examine the influence of concurrent heavy weight training (HWT) along with endurance training on running economy (CR) and the VO(2) kinetics in endurance athletes. Fifteen triathletes were assigned to endurance with strength (ES) training and endurance only (E) training for 14 weeks. The training program was similar, except ES performed two NWT sessions a week. Before and after the training period, the

subjects performed the tests such as an incremental field running the test for determination of VO(2 Max) and the velocity associated (V(VO2 Max)), the second ventilatory threshold (VT(2)), a 3000 -m run at a constant velocity, calculated to require 25% of the difference between VO(2 Max) and VT(2) to determine CR and the characteristics of the VO(2) kinetics, maximal hopping tests to determine maximal mechanical power and lower-limb stiffness, maximal concentric lower-limb strength measurements. Results showed that after the training period, maximal strength was increased ($P<0.01$) in ES but remained unchanged in E. Hopping power decreased in E ($P<0.05$). After training, the economy ($P<0.05$) and hopping power ($P<0.001$) were greater in ES than in E. VO(2 Max), leg hoping stiffness, and the VO(2) Kinetics were not significantly affected by training either in ES or E. The study was concluded that additional heavy weight training (HWT) led to improved maximal strength and running economy with no significant effects on the VO(2) kinetics pattern in heavy exercise.

**Yamamoto, K. et al. (2001)** classified the effects of endurance training on resting and post-exercise cardiac autonomic control. To achieve the purpose, the subjects were divided into two groups, namely the endurance training group (N=seven ) and the control group (N=five). The Training Group underwent endurance training for six weeks, and the control group was not exposed to any training. Endurance training induces reductions in both resting and post-exercise heart rate (HR). Suppose adaptation in cardiac autonomic regulation was a contributing factor in these reductions. In that case, changes in the cardiac autonomic nervous system (ANS) should correspond to those in HR during an endurance training program. The changes in resting and post-exercise HR variabilities over a six-week training program were noted. HR variability was measured five times in an endurance training group (N

=seven) and four times in a control group (N =five) during the study. Endurance training decreased HR and high indices of parasympathetic modulation measured at rest and during post-exercise recovery periods. The study was concluded that six weeks of endurance training made changes in cardiac ANS modulation partly contribute to a decrease in HR at rest and during the post-exercise recovery period. That adaptation of the cardiac autonomic control occurs sooner in immediate post-exercise periods than at rest.

## 2.5 STUDIES ON SKILL PERFORMANCE VARIABLES

**Yann Le Mansec., Jerome, P., et al. (2018)** evaluate muscle fatigue's effects on badminton performance during a smash stroke. In total, 17 young, well-trained players completed 20 forehand smashes twice (pre-fatigue and post fatigue protocol), and both speed and precision of the strokes were measured. The fatigue protocol consisted of 10 series of 10 maximal countermovement jumps (3-s rest in between) followed by eight lunges. Perception of effort and countermovement-jump performance during each series were also measured to assess fatigue.Shuttlecock speed decreased moderately (-3.3%) but significantly after the fatigue protocol ($P < .001$, $\eta p2=.671$). Precision significantly decreased after the fatigue protocol (-10.3%, $P = .001$, $\eta p2=.473$). The decrease in precision was mainly due to an increased number of faults ($P = .006$, $\eta p2=.378$, $dz = 0.756$) and to a decrease in accuracy ($P = .066$, $\eta p2=.195$, $dz = 0.478$).The present study showed that fatigue impairs performance during specific badminton skills. Moreover, by showing a slight decrease in speed and a large decrease in accuracy of the shuttlecock when fatigue is experienced, the present study suggested that, as previously observed in other racket sports, the speed of the missile appears to be the key factor used by the players to win

the rally. Therefore, coaches and physical trainers should develop interventions aiming to limit the negative impact of fatigue on badminton strokes.

**Ibrahim Hassan and Ibrahim Hamed (2017)** investigated how core training on skill performance for badminton players is sufficient. The current study aimed to examine the effects of core stability training on dynamic balance and smash stroke velocity and accuracy performance. Twenty badminton players under 19 years were divided into the core training group (n = 10) and the control group (n = 10). The core stability training group completed eight weeks training program, while the control group did only their badminton traditional training. Core stability training intervention's effectiveness was assessed by performing core stability tests with four positions, dynamic balance test, and forehand smash stroke performance test. Significant improvement was obtained only in the training group for core muscle endurance. The total reached a distance of three directions in the star excursion balance test and smashing velocity and accuracy variables ($p < 0.05$). Consequently, eight weeks of core stability training improved maintained optimum lower limb dynamic balance and increased the performance level of smash stroke in young badminton players.

**JitenSingh. et al. (2016)** The purpose of the study was to determine the effect of game-specific training on selected Badminton skills in School Badminton players. A total of 15 Badminton male players were selected from Don Bosco School, Dibrugarh, for the study. The age group of the subject was ranged from 10-15 years. The French Short Service test and Poole long Service test, was administrated in this study. A pre-test and post-test randomized Single group design were employed to collect the data. The t-test was used for statistical analysis to determine the difference

between pre-test and post-test after six weeks of the training program. The level of significance was set at 0.05 confidences. The analysis of data revealed that statically there was a significant difference in short service ((tabulated t0.05 (14) =2.145 < 6.33) and high service (tabulated t0.05 (14) =2.145 < 4.32) for pre-test and post-test on the experimental group.

**Manikandan S. (2016)** studied the significance of particular "anthropometric measurements," "bio-motor abilities," and "skill variables" of the playing capacity of badminton players. Players need to perform at their limits of speed, agility, mobility, stamina, and strength at the elite level. For the study, 40 women badminton players were selected randomly. "Pearson product-moment correlation" resulted in a considerable link between the playing capacity and speed, weight, height, serving, flexibility, and clear overhead shot among badminton players. As per the result, the multiple correlation coefficient for predictors like speed, arm length, flexibility, and serving and overhear clear shot is 0.58, which generates the highest multiple correlations with badminton playing ability. There is a highly significant relationship between the predictor variable selected for the multiple regression equation with the players' playing ability. Along with this, the height, weight, speed, and flexibility also have a considerable connection with the players' playing capability.

**Laishram Bikram Singh and Dr. SentuMitra (2016)** The purpose of this study was to determine the effect of seven weeks training program on sub-junior badminton players' playing ability. For the study, 20 male and female badminton players participated in the summer coaching camp held at Lakshmibai National Institute of Physical Education, Guwahati, with ages ranged 12.9 ± 2.1 years. For determining the badminton playing ability, the "Lockhart & McPherson Badminton

Wall Volley Test" was used as a criterion measure. Pre-test data were collected at the start of the seven weeks training program, and also Posttest data were collected after the completion of the seven weeks training program. Descriptive statistics and independent t-test were used as statistical techniques for the study. The study results revealed that the seven weeks of training had significantly improved the playing ability of junior badminton players.

**Sepideh.K., Fatemeh.A. (2015)** investigated the improvement of skills performance of Badminton players after visual training. Seven female badminton players that have play badminton for at least five years participated in this study. Routine and basic ocular and eye examinations were done for every subject. Vergences and accommodation facility and hand-eye coordination (HEC) were recorded for every subject at the beginning of this study. Specific training for the development of vergences and accommodation facilities and HEC was done for all subjects. Vergences and accommodation facilities and HEC have been measured and trained for ten sessions. The test result indicates that training could benefit athletes. It means our sports vision training program is developed to strengthen and enhanced individual motor skills. We discuss our recommendations with athletes and their coaches, and we measured their sports skills with collaboration with their professional coaches. The results show there is a significant improvement in Badminton players after visual training.

**Eiji, W., Takaaki, M.(2011)** concluded the relationship between motor skill and competition from the collegiate badminton athletes present study investigated the index of talent for collegiate badminton athletes. Subjects were 20 university badminton athletes (10 men and ten women, from 18 to 22 years old). Male athletes

who participated in intercollegiate badminton championships were contrasted with the other athletes. Female athletes ranked in the top 16 in intercollegiate badminton championships were contrasted with the other athletes. Body-based (3 items) and sensorimotor (6 items) characteristics were measured. Our results showed a positive correlation between the competition resulting in the pro-agility test in men and the vertical jump in women. Our findings suggest that adolescent badminton athletes with higher (body-based or sensorimotor) scores have higher career possibilities in Badminton.

**Tiwari, L., Rai, V., and Srinet, S. (2011)** proposed research to identify the connection between badminton players' performance, speed, agility, shoulders explosive strength, and muscular endurance. The age of selected players for the study was between 20 to 25 years. To evaluate the speed "50-meter dash in sec.," Agility "4 x 10 meters shuttle Run in sec.," Shoulder strength "pul50-meter numbers," explosive strength "standing broad jump in meters," muscular endurance "sit-ups in numbers per min," on the other hand, a panel of experts evaluated the performance of Basit-ups based on technique, skills and matched results. The research outcome shows that there is a significantly negative relationship between speed, agility, and playing ability. Speed is the fastness of limb movement, and regardless there is a leg or arm of the player at the time of smashing. How a player changes the angle of his body efficiently and effectively is agility. A significant relationship was found between playing capability and explosive strength. The product of speed and strength is explosive strength. Explosive strength is the muscular unit's capacity or amalgamation of the muscular unit to utilize maximal force in a minimal period. The ability of a muscle to carry out repetitious compression is called muscular endurance. The abdomen's core strength is necessary for badminton players; therefore, for effective muscular

contraction, abdomen endurance is required. Hence, it is concluded from the study that all the bio-meter variables have a considerable connection with the playing capability of players.

**Russell, M. et al. (2011)** studied the influence of exercise on skill proficiency in soccer. They documented that the ability to maintain technical performances (i.e., skills) throughout soccer match-play was crucial in determining competitive fixtures' outcome. Consequently, coaches dedicate a large proportion of time to practicing isolated skills, such as passing, shooting, and dribbling. Unlike other elements that contribute to team-sport performances, it was unusual for coaches to use methods other than observations to assess changes resulting from technical training. Researchers have employed various tests to measure isolated soccer skills; however, reliance on outcome measures that include several contacts (ball juggling tasks), time (dribbling tasks), and points scored (criterion-based passing and shooting tests) means that the outcomes were difficult for coaches to interpret. Skill tests that use video-analysis techniques to measure ball speed, precision, and success of soccer skills offer valid and reliable alternatives. Although equivocal results were published, skill performances could be affected by various factors that threaten homeostasis, including match-related fatigue, dehydration, and reductions in blood glucose concentrations. While acknowledging methodological constraints associated with using skill tests with limited ecological validity and cognitive demands, the effects of these homeostatic disturbances might vary according to the type of skill being performed. Shooting performances appear most susceptible to deterioration after exercise. Strategies such as aerobic training, fluid-electrolyte provision, and acute carbohydrate supplementation have improved proficiency in technical actions performed after soccer-specific exercise. However, mechanisms that cause

deterioration in skill during soccer-specific exercise remain fully elucidated, and strategies to optimize technical performance throughout match-play were warranted.

## 2.6 SUMMARY OF THE LITERATURE

Study reviews relevant to the Sand and Aquatic training selected Bio-motor, physiological, and Skill-related performance variables were categorized and summarized in this chapter. The literature mentioned above indicates that there has been a significant change in bio-motor, physiological, and skill-related performance variables due to sand and aquatic training. The related literature found that there were scope for research in the sand and aquatic training on selected bio-motor, physiological, and Skill performance variables among the Badminton players.

The review was present in five parts, such as Aquatic Training (20), Sand Training (20), Bio-motor Variables (10), Physiological Variables (10), and Skill Performance Variables (10). All the research studies discussed in this section have shown that the Sand and Aquatic training contributes significantly to developing dependent variables. The research studies examined were obtained from the publications available on the website and some university libraries. Based on the information collected, the investigator has formulated the appropriate methodology for this study, as presented in Chapter III.