CHAPTER II

REVIEW OF RELATED LITERATURE

A study of relevant literature is an inevitable and essential step to get full picture of what has been done with regard to the problem under study. Such a review brings about a deep and clear perspective of the overall field.

The investigator has traced out different types of research works like dissertations, thesis, journals, relevant studies, varieties of relevant books on physical education and sports sciences. The series of relevant studies related to the problem under study have been presented in this chapter under the following three categories:

1. Studies on continuous training and Interval training
2. Studies on Interval Training
3. Studies on Training effects on Physical variables
4. Studies on Training Effects on Physiological variables
5. Studies on Training effects on Biochemical variables

In this chapter start with a short summary on the impact of previous research conducted on the present study. A review of relevant literature is essential to get a full picture of what is to be done with regard to the present study. Innovative ideas and reforms are being introduced almost in all fields of the study. The relevant literature pertaining to the present study has been abstracted in

the chapter to provide the background material, to evaluate the significance of this study as well as to interpret its findings.

2.1 STUDIES ON CONTINOUS TRAINING AND INTERVAL TRAINING

Chapman DW, et.al., (2009) conducted a study on examine the effectiveness of a time-limited and distance regulated Continuous training program on subelite field hockey players. Subjects comprised 22 women (26.1 +/- 4.5 years, 62.8 +/- 7.4 kg, 1.7 +/- 0.9 m) and 22 men (22.1 +/- 3.2 years, 74.9 +/- 5.4 kg, 1.8 +/- 0.5field hockey players. Performance tests included a standard 20-m multiple-stage shuttle run (MSSR), a 1000-m repeated-effort (x3) time trial (RTT), and a 100-mrepeated-effort (x3) shuttle run (RSR) in an ascending pyramid order. The Continuous training program was administered separately to the women and men after a traditional, single-peak, 4-week mesocycle, with the fourth week for recovery. Continuous Training consisted of an average total sprint distance of 3000 m per session during a 20-week data collection period, with testing administered pre and post. Initial athlete profiling showed a significant ($p < 0.05$) gender difference on all performance tests. The MSSR results were 8.6 +/- 2.5 (range 6.7-10.7) and 12.1 +/- 2.4 (10.2-13.5) women and men, respectively. The RTT and RSR times for women and men were 5:34 +/- 0:30 seconds (4:31-6:21), 5:14 +/- 0:30 seconds (4:27-6:02), 4:12 +/- 0:13 seconds (3:50-4:36), and 4:06 +/- 0:13 seconds (3:47-6:02), respectively. After 20 weeks of training, a

small to moderate effect size (ES) was calculated for the women's (n = 12) MSSR (ES = 0.74) and RSR (ES = 0.50) results. A distinct improvement in the MSSR resulted after Continuous training for men (n = 16), with a moderate ES (1.34). In contrast, completion times in RSR were marginally reduced, with a small ES (0.49). The findings demonstrate that a 3000-m interval-based conditioning program, when conducted in conjunction with normal-skill game play training, can lead to significant improvements in player conditioning during a competitive season. Future research should employ modified performance tests that more accurately reflect the nature of the game.

Gilbertson NM et.al (2019) designed to evaluate the 16 weeks diabetes prevention program (DPP) combined with instructed run sprint interval training (INT) or moderate-intensity continuoustraining (MICT) on glycemic control, body composition, fitness, exercise adherence, and perceived exercise enjoyment in sedentary, adults with prediabetes. Participants completed three weekly supervised sessions of INT (4-10 bouts of 30 s maximal sprints followed by a 4 min active recovery) or MICT (30-60 min at 45-55% HRR) exercise coupled with the DPP for 16 weeks. At baseline, 8 and 16 weeks, participants completed fitness and clinical assessments as well as questionnaires to assess group and time differences. Twenty-nine study participants (INT n = 17, MICT n = 12) were randomized, however, significantly (p = 0.024) more participants withdrew from the INT (n = 11) than MICT (n = 4) treatment. There

was no significant difference between groups in perceived exercise enjoyment, but, the MICT group significantly improved their perceived exercise enjoyment (10.8 ± 14.2; $p = 0.021$) from baseline to 16 weeks. Both INT and MICT groups decreased their body weight (2.0 ± 0.8 vs. -5.5 ± 1.4 kg; $p < 0.001$), BMI (-0.6 ± 0.3 vs. -2.1 ± 0.5 kg/m^2; $p < 0.001$), body fat mass (1.4 ± 0.6 vs. -4.2 ± 1.0 kg; $p < 0.001$), fasting glucose (-0.09 ± 0.01 vs. -0.18 ± 0.02 mmol/L; $p = 0.020$), and HbA1c (-0.21 ± 0.09 vs. -0.12 ± 0.12%; $p = 0.001$), respectively, however, the MICT had greater reductions (GxT: $p \leq 0.05$) in body weight, BMI, and body fat than the INT group. Sixteen weeks of MICT is adhered to better and elicits greater improvements in body composition than INT. Nevertheless, both interventions similarly reduced fasting glucose and HbA1c in adults with prediabetes, suggesting either treatment could be effective for T2D prevention.

Falz R et al. (2019) examined the acute responses to ST, high-intensity interval training (HIIT) and moderate-intensity continuous training (MCT). Twelve young male subjects (age 23.4 ± 2.6 years; BMI 23.7 ± 1.5 kg/m^2) performed an incremental exertion test and were randomized into HIIT (4×4-min intervals), MCT (continuous cycling) and ST (five body-weight exercises) which were matched for training duration. The cardiopulmonary (impedance cardiography, ergo-spirometry) and metabolic response were monitored. Similar peak blood lactate responses were observed after HIIT and ST (8.5 ± 2.6 and 8.1 ± 1.2 mmol/l, respectively; $p = 0.83$). The training impact time was

90.7 ± 8.5% for HIIT and 68.2 ± 8.5% for MCT ($p < 0.0001$). The mean cardiac output was significantly higher for HIIT compared to that of MCT and ST (23.2 ± 4.1 vs. 20.9 ± 2.9 vs. 12.9 ± 2.9 l/min, respectively; $p < 0.0001$). VO_{2max} was twofold higher during HIIT compared to that observed during ST (2529 ± 310 vs. 1290 ± 156 ml; $p = 0.0004$). Among the components of ST, squats compared with push-ups resulted in different heart rate (111 ± 13.5 vs. 125 ± 15.7 bpm, respectively; $p < 0.05$) and stroke volume (125 ± 23.3 vs. 104 ± 19.8 ml, respectively; $p < 0.05$). Despite an equal training duration and a similar acute metabolic response, large differences with regard to the training impact time and the cardiopulmonary response give evident. HIIT and MCT, but less ST, induced a sufficient cardiopulmonary response, which is important for the preventive effects of training; however, large differences in intensity were apparent for ST

Liu JX et.al. (2019) studied effects of aerobic exercise on fat loss and cardio metabolic health are well-documented, but it is unknown whether a high-intensity interval training (HIIT) elicit a greater health benefit in obese children and adolescents. Relevant studies in Pubmed, Web of Science, Embase, the Cochrane Library, EBSCO, and CNKI will be searched for studies with language restriction in English and Chinese, which were published from inception to December 1, 2018. Only randomized controlled trials of HIIT on pediatric obesity will be included, and observational studies, prospective cohort studies, and

systematic reviews will be excluded. Two reviewers will independently screen the studies; risk of bias assessment and data extraction, and the results are inconsistent when discussed or resolved by a third reviewer. Data analysis and synthesis will be completed by the Revman 5.3 software and Stata 12.0 software. This study will be conducted by following the guideline of the Preferred Reporting Items for Systematic Review and Meta-analysis Protocols. This study will be conducted by previously published data, thus ethics approval is not required. This finding will be published in a related peer-reviewed journal and present it at international conferences.

Williams CJ et al. (2019) combined data from different laboratories to compare O_{2peak} trainability between various volumes of interval training and Moderate Intensity Continuous Training (MICT). For interval training, volumes were classified by the duration of total interval time. High-volume High Intensity Interval Training (HIIT) included studies that had participants complete more than 15 min of high intensity efforts per session. Low-volume HIIT/Sprint Interval Training (SIT) included studies using less than 15 min of high intensity efforts per session. In total, 677 participants across 18 aerobic exercise training interventions from eight different universities in five countries were included in the analysis. Participants had completed 3 weeks or more of either high-volume HIIT (n = 299), low-volume HIIT/SIT (n = 116), or MICT (n = 262) and were predominately men (n = 495) with a mix of healthy, elderly

and clinical populations. Each training intervention improved mean O_{2peak} at the group level ($P < 0.001$). After adjusting for covariates, high-volume HIIT had a significantly greater ($P < 0.05$) absolute O_{2peak} increase (0.29 L/min) compared to MICT (0.20 L/min) and low-volume HIIT/SIT (0.18 L/min). Adjusted relative O_{2peak} increase was also significantly greater ($P < 0.01$) in high-volume HIIT (3.3 ml/kg/min) than MICT (2.4 ml/kg/min) and insignificantly greater ($P = 0.09$) than low-volume HIIT/SIT (2.5 mL/kg/min). Based on a high threshold for a likely response (technical error of measurement plus the minimal clinically important difference), high-volume HIIT had significantly more ($P < 0.01$) likely responders (31%) compared to low-volume HIIT/SIT (16%) and MICT (21%). Covariates such as age, sex, the individual study, population group, sessions per week, study duration and the average between pre and post O_{2peak} explained only 17.3% of the variance in O_{2peak} trainability. In conclusion, high-volume HIIT had more likely responders to improvements in O_{2peak} compared to low-volume HIIT/SIT and MICT.

Way KL et.al. (2019) compared HIIT versus MICT on central arterial stiffness and 24h BP outcomes by systematic review and meta-analysis.Eligible studies were exercise training interventions (≥4weeks) that included both HIIT and MICT and reported central arterial stiffness, as measured by pulse wave velocity and augmentation index and/or 24h BP outcome measures. HIIT was found to be superior to MICT for reducing night-time diastolic BP (ES: -0.456,

95% CI: -0.826 to -0.086mmHg; P=0.016). A near-significant greater reduction in daytime systolic (ES: -0.349, 95% CI: -0.740 to 0.041mmHg; p=0.079) and diastolic BP was observed with HIIT compared to MICT (ES: -0.349, 95% CI: -0.717 to 0.020mmHg; p=0.063). No significant difference was found for other BP responses or arterial stiffness outcomes. HIIT leads to a superior reduction in night-time diastolic BP compared to MICT. Furthermore, a near-significant greater reduction in daytime BP was found with HIIT compared to MICT. No significant difference was observed for changes to central arterial stiffness between HIIT and MICT.

Gunnarsson TP et.al. (2019) examined adaptations in muscle oxidative capacity and exercise performance induced by two work- and duration-matched exercise protocols eliciting different muscle metabolic perturbations in trained individuals. Thirteen male subjects ($\dot{V}O_2$-max 53.5 ± 7.0 $mL \cdot kg^{-1} \cdot min^{-1}$) (means ± SD) performed 8 weeks (three sessions/week) of training consisting of 60 min of moderate intensity continuous cycling (157 ± 20 W) either without (C) or with (C+S) inclusion of 30-s sprints (473 ± 79 W) every 10 min. Total work performed during training was matched between groups. Muscle biopsies and arm venous blood were collected before as well as immediately and 2 h after exercise during the first and last training session. Plasma epinephrine and lactate concentrations after the first and last trainingsession were 2-3-fold higher in C+S than in C. After the first and last training session, muscle phosphocreatine and pH

were lower (12-25 mmol·kg d.w.$^{-1}$ and 0.2-0.4 units, respectively) and muscle lactate higher (48-64 mmol·kg d.w.$^{-1}$) in C+S than in C, whereas exercise-induced changes in muscle PGC-1α mRNA levels were similar within- and between-groups. Muscle content of cytochrome c oxidase IV and citrate synthase (CS) increased more in C+S than in C, and content of CS in type II muscle fibers increased in C+S only (9-17%), with no difference between groups. Performance during a 45-min time-trial improved by 4 ± 3 and 9 ± 3% in C+S and C, respectively, whereas peak power output at exhaustion during an incremental test increased by 3 ± 3% in C+S only, with no difference between groups. In conclusion, addition of sprints in moderate intensity continuous exercise causes muscle oxidative adaptations in trained male individuals which appear to be independent of the exercise-induced PGC-1α mRNA response. Interestingly, time-trial performance improved similarly between groups, suggesting that changes in content of mitochondrial proteins are of less importance for endurance performance in trained males.

Viana RB et.al. (2019) compared the effects of interval training and moderate-intensity continuous training(MOD) on body adiposity in humans, and to perform subgroup analyses that consider the type and duration of interval training in different groups. English-language, Spanish-language and Portuguese-language searches of the electronic databases PubMed and Scopus were conducted from inception to 11 December 2017. Studies that met the

following criteria were included: (1) original articles, (2) human trials, (3) minimum exercise training duration of 4 weeks, and (4) directly or indirectly compared interval training with MOD as the primary or secondary aim. Of the 786 studies found, 41 and 36 were included in the qualitative analysis and meta-analysis, respectively. Within-group analyses showed significant reductions in total body fat percentage (%) (interval training: -1.50 [95% CI -2.14 to -0.86, p<0.00001] and MOD: -1.44 [95% CI -2.00 to -0.89, p<0.00001]) and in total absolute fat mass (kg) (interval training: -1.58 [95% CI -2.74 to -0.43, p=0.007] and MOD: -1.13 [95% CI -2.18 to -0.08, p=0.04]), with no significant differences between interval training and MOD for total body fat percentage reduction (-0.23 [95% CI -1.43 to 0.97], p=0.705). However, there was a significant difference between the groups in total absolute fat mass (kg) reduction (-2.28 [95% CI -4.00 to -0.56], p=0.0094). Subgroup analyses comparing sprint interval training (SIT) with MOD protocols favour SIT for loss of total absolute fat mass (kg) (-3.22 [95% CI -5.71 to -0.73], p=0.01). Supervised training, walking/running/jogging, age (<30 years), study quality and intervention duration (<12 weeks) favourably influence the decreases in total absolute fat mass (kg) observed from interval training programmes; however, no significant effect was found on total body fat percentage (%). No effect of sex or body mass index was observed on total absolute fat mass (kg) or total body fat percentage (%). Interval training and

MOD both reduce body fat percentage (%). Interval trainingprovided 28.5% greater reductions in total absolute fat mass (kg) than MOD.

Castro A et.al. (2019) investigated baseline serum and skeletal muscle metabolomics profile and its associations with maximal power output (MPO) gains in response to 8-week of continuous endurance training (ET) and high-intensity interval training (HIIT) programs matched for total units of exercise performed (the TIMES study). Eighty healthy sedentary young adult males were randomized to one of three groups and 70 were defined as completers (> 90% of sessions): ET (n = 30), HIIT (n = 30) and control (CO, n = 10). For the CO, participants were asked to not exercise for 8 weeks. Serum and skeletal muscle samples were analyzed by 1H-NMR spectroscopy. The targeted screens yielded 43 serum and 70 muscle reproducible metabolites (intraclass > 0.75; coefficient of variation < 25%). Associations of baseline metabolites with MPO trainability were explored within each training program via three analytical strategies: (1) correlations with gains in MPO; (2) differences between high and low responders to ET and HIIT; and (3) metabolites contributions to the most significant pathways related to gains in MPO. The significance level was set at $P < 0.01$ or false discovery rate of 0.1. The exercise programs generated similar gains in MPO (ET = 21.4 ± 8.0%; HIIT = 24.3 ± 8.5%). MPO associated baseline metabolites supported by all three levels of evidence were: serum glycerol, muscle alanine, proline, threonine, creatinine, AMP and pyruvate for ET, and serum lysine,

phenylalanine, creatine, and muscle glycolate for HIIT. The most common pathways suggested by the metabolite profiles were aminoacyl-tRNA biosynthesis, and carbohydrate and amino acid metabolism. We suggest that MPO gains in both programs are potentially associated with metabolites indicative of baseline amino acid and translation processes with additional evidence for carbohydrate metabolism in ET.

Sjöros T et.al. (2019) tested the effects of SIT and moderate-intensity continuous training(MICT) on IMCL and EMCL accumulation in a randomized controlled setting in two different study populations; healthy untrained men (n 28) and subjects with type 2 diabetes (T2D) or prediabetes (n 26). Proton magnetic resonance spectroscopy (^{1}H MRS) was used to determine IMCL and EMCL in the Tibialis anterior muscle (TA) before and after a 2-week exercise period. The exercise period comprised six sessions of SIT or MICT cycling on a cycle ergometer. IMCL increased after SIT compared to MICT ($P = 0.042$) in both healthy and T2D/prediabetic subjects. On EMCL the training intervention had no significant effect. In conclusion, IMCL serves as an important energy depot during exercise and can be extended by high intensity exercise. The effects of high intensity interval exercise on IMCL seem to be similar regardless of insulin sensitivity or the presence of T2D.

Cuddy TF et.al. (2019) determined the effectiveness of an 8 wk reduced-exertion high-intensity interval training (REHIT) at improving cardiorespiratory

fitness (CRF) and positively modifying cardiometabolic health in the workplace environment. Participants (n = 32) were randomized to two groups: (1) One group (n = 16) was prescribed an 8 wk REHIT program, and (2) one group (n = 16) was prescribed moderate-intensity continuous training (MICT). Cardiometabolic risk factors and CRF were measured at baseline and 8 wks. After 8 wks, changes in CRF (REHIT, 12%; MICT, 7%), systolic blood pressure (REHIT, -5%; MICT, -2%), waist circumference (REHIT, -1.4%; MICT, -0.3%), and metabolic syndrome (MetS) severity (MetS z-score: REHIT, -62%; MICT, 27%) were more favorable ($p < 0.05$) in the REHIT group relative to the MICT group. Interestingly, there was a significantly greater proportion of participants in the REHIT group (75%, 9/12) who had a favorable change in the MetS z-score ($\Delta > -0.60$) relative to the MICT group (47%, 7/15). The main finding of the present study is that 8 wks REHIT elicited more potent and time-efficient improvements in CRF and cardiometabolic health when compared to traditional MICT. This study provides critical evidence for implementation of the sprint interval training (SIT) paradigm from the scientific literature into a real-world workplace setting.

Schaun GZ et.al. (2019) studied the neuromuscular adaptations between ergometer-based high-intensity interval training (HIIT-T; n = 15), whole-body high-intensity interval training (HIIT-WB; n = 12) and moderate-intensity continuous training (MICT; n = 14) were compared in forty-one healthy

men randomized to 16 weeks of training (3x per week). Two-way repeated measures analysis of variance (ANOVA) showed countermovement (CMJ) and squat (SJ) jump height (HIIT-T: 8.5 ± 13.3%; 3.1 ± 9.7%, HIIT-WB: 6.4 ± 9.8%, 10.4 ± 16.1% and MICT: 2.2 ± 9.5%; 4.4 ± 12.1%, respectively), SJ peak power (HIIT-T: 1.7 ± 3.9%; HIIT-WB : 6.4 ± 7.9%; MICT: 0.5 ± 6.5%) and CMJ rate of force development (HIIT-T: 58.1 ± 50.5%; HIIT-WB: 36.9 ± 54.2%; MICT: 38.4 ± 64.3%) improved similarly in all training groups (all $p < 0.05$). CMJ peak power increased only after HIIT-T (4.3 ± 5.5%) and HIIT-WB (4.5 ± 5.2%), while no differences were observed in both the rectus femoris and vastus lateralis maximal electromyographic amplitude. Finally, marked improvements were also observed in the number of repetitions in the HIIT-WB protocol at the eighth week, with no further improvement at the sixteenth week. These data suggest that 16 weeks of HIIT-WB is capable to improve neuromuscular function to a similar extent as HIIT-T and MICT.

Ramírez-Vélez R et.al. (2019) determined the effects of moderate (MCT)- versus high-intensity interval training (HIT) on vascular function parameters in physically inactive adults. We hypothesized that individualized HIT prescription would improve the vascular function parameters more than the MCT in a greater proportion of individuals. Twenty-one inactive adults were randomly allocated to receive either MCT group (60-75% of their heart rate reserve, [HRR] or HIT group (4 min at 85-95% of peak HRR), 3 days a week for 12 weeks.

Vascular function (brachial artery flow-mediated dilation, FMD [%], normalized brachial artery flow-mediated dilation, FMDn [%], aortic pulse wave velocity, PWV [$m \cdot s^{-1}$], AIx, augmentation index: aortic and brachial [%]), were measured at baseline and over 12 weeks of training. In order for a participant to be considered a responder to improvements in vascular function parameters (FMDn and PWV), the typical error was calculated in a favorable direction. FMD changed by - 1.0% (SE 2.1, d = 0.388) in the MCT group, and + 1.8% (SE 1.8, d = 0.699) in the HIT group (no significant difference between groups: 2.9% [95% CI, - 3.0 to 8.8]. PWV changed by + 0.1 $m \cdot s^{-1}$ (SE 0.2, d = 0.087) in the MCT group but decreased by - 0.4 $m \cdot s^{-1}$ in the HIT group (SE 0.2, d = 0.497), with significant difference between groups: - 0.4 [95% CI, - 0.2 to - 0.7]. There was not a significant difference in the prevalence of no-responder for FMD (%) between the MCT and HIT groups (66% versus 36%, P = 0.157). Regarding PWV ($m \cdot s^{-1}$), an analysis showed that the prevalence of no-responder was 77% (7 cases) in the MCT group and 45% (5 cases) in the HIT group (P = 0.114). Under the conditions of the present study, both groups experienced changed in vascular function parameters. Compared to MCT group, HIT is more efficacious for improving FMD and decreasing PWV, in physically inactive adults.

Tew GA et.al. (2019) assessed the feasibility and acceptability of two common types of exercise training-high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT)-in adults with Crohn's disease

(CD). In this mixed-methods pilot trial, participants with quiescent or mildly-active CD were randomly assigned 1:1:1 to HIIT, MICT or usual care control, and followed up for 6 months. The HIIT and MICT groups were offered three exercise sessions per week for the first 12 weeks. Feasibility outcomes included rates of recruitment, retention, outcome completion, and exercise attendance. Data were collected on cardiorespiratory fitness (e.g., peak oxygen uptake), disease activity, fatigue, quality of life, adverse events, and intervention acceptability (via interviews). Over 17 months, 53 patients were assessed for eligibility and 36 (68%) were randomised (47% male; mean age 36.9 [SD 11.2] years); 13 to HIIT, 12 to MICT, and 11 to control. The exercise session attendance rate was 62% for HIIT (288/465) and 75% for MICT (320/429), with 62% of HIIT participants (8/13) and 67% of MICT participants (8/12) completing at least 24 of 36 sessions. One participant was lost to follow-up. Outcome completion rates ranged from 89 to 97%. The mean increase in peak oxygen uptake, relative to control, was greater following HIIT than MICT (2.4 vs. 0.7 mL/kg/min). There were three non-serious exercise-related adverse events, and two exercise participants experienced disease relapse during follow-up. The findings support the feasibility and acceptability of the exercise programmes and trial procedures.A definitive trial is warranted. Physical exercise remains a potentially useful adjunct therapy in CD

Tine Kartinah N et.al. (2019) studied the effects of those exercise formulas on irisin level changes as beiging agent are not known. In addition,

metabolic states may affect the irisin responses to those exercise formulas. Therefore, this study was aimed to determine the different effects of exercises using HIIT and CMIT on circulating and tissue irisin levels in normal and abnormal metabolic conditions (obese). Sixteen male Sprague-Dawley rats (8 weeks of age) were randomized to 4 groups according to training regimens (HIIT and CMIT) and metabolic conditions (normal and abnormal/obese). The groups are (1) HIIT on normal metabolic (n=4), (2) CMIT on normal metabolic (n=4), (3) HIIT on abnormal metabolic (n=4), and (4) CMIT on abnormal metabolic (n=4). Abnormal metabolic condition was induced with high fat diet (19% fat) for 8 weeks in obese rats. Irisin levels in serum, skeletal muscle, and white adipose tissue were evaluated by ELISA. Serum irisin levels were shown significantly higher in normal metabolic compared to abnormal metabolic condition ($P<0.001$). The effect of interaction between metabolic condition and exercise formula was found ($P<0.01$) on adipose irisin levels. The effect of HIIT was shown significantly more effective on adipose irisin levels, compared with CMIT in abnormal metabolic conditions. However, no significant differences of skeletal muscle irisin levels were found in both normal and abnormal metabolic subjects ($P>0.05$). Regarding exercise formula, no different effects were found between HIIT and CMIT on skeletal muscle irisin levels in both metabolic conditions ($P>0.05$). The similar findings were observed in serum irisin levels ($P>0.05$). The exercise effects in abnormal metabolic condition might be more adaptable in

maintaining the irisin levels in skeletal muscle and induce the irisin uptake from circulation into adipose tissue. In addition, HIIT might be more involved to induce irisin uptake into adipose tissue; thus it might have the significant role in beiging process. However, further research about how the HIIT formula affects the regulation mechanisms of irisin uptake into adipose tissue is still warranted.

Poon ET et.al. (2019) compared the psycho-perceptual responses after a single session of HIIT versus moderate-intensity continuous exercise (MICE) and vigorous-intensity continuous exercise (VICE) in twelve young and twelve middle-aged insufficiently active males respectively. Using a randomized cross-over design, participants undertook three main trials consisting of: HIIT (10 x 1-min run at 100% VO_{2max} interspersed with 1-min active recovery), MICE (40-min run at 65% VO_{2max}) and VICE (20-min run at 80% VO_{2max}). Affective responses, self-efficacy and exercise preference were assessed for each trial. Both HIIT and VICE showed more positive in-task affective responses than MICE in young adults, while middle-aged adults reported more positive responses in both HIIT and MICE than in VICE. However, middle-aged adults displayed significantly lower exercise task self-efficacy scores towards HIIT (42.7 ± 25.3) and VICE (49.2 ± 23.9) than MICE (63.4 ± 18.3, both $P < 0.01$). Additionally, only 17% of participants in the middle-aged group reported a preference to engage in HIIT as opposed to either MICE (50%) and VICE (33%). Our finding revealed distinct affective and self-efficacy responses to acute HIIT versus both MICE and VICE

in the two age groups which assists in our understanding of how individuals in various age populations perceive HIIT. This information will assist in the design and implementation of effective exercise programs for public health, especially for insufficiently active individuals.

Landram M et.al. (2019) examined the cardiac autonomic nervous system differences following either continuous vs. discontinuous exercise in males and females. Forty-seven healthy male and female subjects (M=19, F=28; Age=36.95±13.79) underwent a baseline test for VO_{2peak} and tilt table testing. They were assigned to a one-month control period before returning to repeat the testing and then begin one month of either continuous aerobic treadmill work for 30 min at 70% peak heart rate (N=23) or 3 bouts of 10 min at 70% of peak heart rate with two 10-min break periods in between (N=24). Following exercise, both groups demonstrated a significant improvement in VO_{2peak} ($p<0.001$). Treatment differences were detected while tilted in continuous as a decreases in the percentage of instances within an hour that the normal sinus interval exceeds 50 ms ($p=0.036$) and in the high-frequency component ($p=0.023$). While supine, the discontinuous group saw reduction in heart rate ($p=0.004$), and an increase in high-frequency ($p=0.018$). These data suggest that for healthy people either continuous or discontinuous aerobic training is effective in improving measures of fitness; however discontinuous is better able to improve supine indices of vagal activity on heart rate variability.

Gerber M et.al. (2018) examined whether participation in 12 SIT sessions would lead to different changes in self-determined motivation, affective responses to exercise, cardiorespiratory fitness, physical activity, and depressive symptom severity compared to aerobic exercise training (CAT) in a sample of patients with major depressive disorders (MDD). Methods: Two groups of 25 patients (39 women, 11 men) with unipolar depression were randomly assigned to the SIT or CAT condition (M = 36.4 years, SD = 11.3). Data were assessed at baseline and post-intervention (three weekly 35-min sessions of SIT/CAT over a 4-week period). Self-determined exercise motivation was assessed with a 12-item self-rating questionnaire, affective valence was assessed in each session, prior, during, and after the exercise training using the Feeling Scale (FS). Cardiovascular fitness was measured with a maximal bicycle ergometer test, self-perceived fitness with a 1-item rating scale, physical activity with the International Physical Activity Questionnaire (IPAQ-SF), and depressive symptom severity with the Beck Depression Inventory II (BDi-II). Results: The SIT and CAT groups did not differ with regard to their changes in self-determined motivation from baseline to post-intervention. Participants in the SIT and CAT group showed similar (positive) affective responses *during* and *after* the training sessions. Cardiorespiratory fitness, self-perceived fitness and depressive symptom severity similarly improved in the SIT and CAT group. Finally, significant increases were observed in self-reported physical activity from baseline to post-intervention. However,

these increases were larger in the CAT compared to the SIT group. Conclusion: From a motivational point of view, SIT seems just as suited as CAT in the treatment of patients with MDD. This is a promising finding because according to self-determination theory, it seems advantageous for patients to choose between different exercise therapy regimes, and for their preferences with regard to exercise type and intensity to be considered.

Hwang CL et.al. (2019) conducted randomized controlled trial was twofold: 1) to test if high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT), implemented on a non-weight-bearing all-extremity ergometer, are feasible, well-tolerated and safe in middle-aged/older adults with type 2 diabetes; and 2) to test whether all-extremity HIIT is more effective in improving aerobic fitness than MICT. A total of 58 sedentary individuals with type 2 diabetes (46 to 78 years; 63 ± 1) were randomized to all-extremity HIIT (n = 23), MICT (n = 19) or non-exercise control (CONT; n = 16). All-extremity HIIT and MICT, performed 4×/week for 8 weeks under supervision, resulted in no adverse events requiring hospitalization or medical treatment. Aerobic fitness (VO_{2peak}) improved by 10% in HIIT and 8% in MICT and maximal exercise tolerance increased by 1.8 and 1.3 min, respectively ($P \leq 0.002$ vs. baseline; $P \geq 0.9$ for HIIT vs. MICT). In conclusion, all-extremity HIIT and MICT are feasible, well-tolerated and safe and result in similar improvements in aerobic fitness in middle-aged/older individuals with type 2

diabetes. These findings have important implications for exercise prescription for diabetic patients; they indicate that all-extremity exercise is a feasible alternative to weight-bearing exercise and those who are unable or unwilling to engage in HIIT may receive similar benefits from MICT.

Tas M et.al. (2019) studied the effects of high-intensity interval and continuous exercise on erythrocytes carbonic anhydrase (CA, EC 4.2.1.1) activity levels were scarcely investigated up until now. Here we present a study focused on the CA activity from erythrocytes of athletes experiencing interval and continuous training for 6 weeks, during cold weather and at high altitude (> 1600 m). We observed a 50% increase in the blood CA activity at the second week after initiation of the training in both interval and continuos running groups, whereas the control group did not experience any variation in the enzyme activity levels. In the trained individuals a mild decrease in their body mass, BMI and an increased [Formula: see text] were also observed. The CA activity returned at the basal values after 4-6 weeks after the training started, probably proving that a metabolic compensation occurred without the need of an enhanced enzyme activity. The unexpected 50% rise of activity for an enzyme which acts as a very efficient catalyst for CO_2 hydration/bicarbonate dehydration, such as the blood CA, deserves further investigations for better understanding the physiologic basis of this phenomenon.

Eichner NZM et.al. (2019) compared high-intensity interval versus continuous training on fasting and postprandial arterial stiffness in people with prediabetes. What is the main finding and its importance? We show, for the first time, that exercise improves the augmentation index during the postprandial state, but not the fasted state, in adults with prediabetes. However, the fasted augmentation index improved in relationship to exercise dose, as assessed by kilocalories per session. Collectively, these findings suggest that short-term exercise can improve arterial compliance in adults with prediabetes. Therefore, lifestyle interventions designed to reduce arterial stiffness could have considerable clinical impact.

Naves JPA et.al. (2018) compared the acute physiological responses of two HIIT and one moderate intensity continuous training (MICT) protocol in young men. A randomised cross-over study with 10 men [age, 28.3 ± 5.5years; weight, 77.3 ± 9.3 kg; height, 1.8 ± 0.1 m; peak oxygen consumption (VO_2peak), 44 ± 11 $mL.kg^{-1}.min^{-1}$]. Participants performed a cardiorespiratory test on a treadmill to assess VO_2peak, velocity associated with VO_2peak (vVO_2peak), peak heart rate (HRpeak) and perceived exertion (RPE). Then participants performed three protocols equated by distance: Short HIIT (29 bouts of 30s at vVO_2peak, interspersed by 30s of passive recovery, 29 min in total), Long HIIT (3 bouts of 4 min at 90% of vVO_2peak, interspersed by 3 min of recovery at 60% of vVO_2peak, 21 min in total) and MICT (21 min at 70% of vVO_2peak). The protocols were

performed in a randomised order with ≥48 h between them. VO_2, HRpeak and RPE were compared. VO_2peak in Long HIIT was significantly higher than Short HIIT and MICT (43 ± 11 vs 32 ± 8 and 37 ± 8 $mL.kg^{-1}.min^{-1}$, respectively, $P < 0.05$), as well as peak HR (181 ± 10 vs 168 ± 8 and 167 ± 11, respectively, $P < 0.05$), and RPE (17 ± 4 vs 14 ± 4 and 15 ± 4, respectively, $P < 0.05$), with no difference between Short HIIT and MICT. In conclusion, Long HIIT promoted higher acute increases in VO_2, HR and RPE than Short HIIT and MICT, suggesting a higher demand on the cardiorespiratory system. Short HIIT and MICT presented similar physiologic and perceptual responses, despite Short HIIT being performed at higher velocities.

2.2 STUDIES ON INTERVAL TRAINING

Naimo MA, de Souza EO, Wilson JM, Carpenter AL, Gilchrist P, Lowery RP, Averbuch B, White TM, and Joy J. (2015) investigated the effects of a high intensity interval training (HIIT) program compared to traditional continuous endurance exercise training. 24 hockey players were randomly assigned to either a continuous or high-intensity interval group during a 4-week training program. The intervalgroup (IG) was involved in a periodized HIIT program. The continuous group (CG) performed moderate intensity cycling for 45-60 min at an intensity that was 65% of their calculated heart rate reserve. Body composition, muscle thickness, anaerobic power, and on-ice measures were assessed pre- and post-training. Muscle thickness was significantly greater in IG (p=0.01) when

compared to CG. The IG had greater values for both Δ peak power ($p<0.003$) and Δ mean power ($p<0.02$). Additionally, IG demonstrated a faster Δ sprint ($p<0.02$) and a trend ($p=0.08$) for faster Δ endurance test time to completion for IG. These results indicate that hockey players may utilize short-term HIIT to elicit positive effects in muscle thickness, power and on-ice performance.

Stevens AW, Olver TT, and Lemon PW. (2015) assessed in 16 trained oarsmen after sprint interval training (SIT) replaced a portion of an endurance-based training program (EBTSIT) vs. an endurance-based program alone (EBTAlone). The EBTSIT involved 10 SIT sessions over 4 weeks, in addition to 12 continuous exercise sessions, 2 anaerobic threshold exercise sessions, and 4 strength training sessions. The EBTAlone consisted of 20 continuous, 6 anaerobic threshold, 2 interval exercise sessions, and 8 strength training sessions. Time-trial performance (2,000-m erg performance) improved with EBTSIT (baseline = 414.6 ± 18.5, post = 410.6 ± 17.5 seconds; $p < 0.001$) but only approached significance in EBTAlone (baseline = 413.0 ± 27.7, post = 411.4 ± 27.9 seconds; $p = 0.06$). In a 60-second "all-out" anaerobic capacity test, peak power output (PPO) increased significantly with EBTSIT (PPO: EBTSIT: baseline = 566 ± 82, post = 623 ± 60 W; $p = 0.02$) but not with EBT Alone (EBTAlone: baseline = 603 ± 81, post = 591 ± 123 W; $p = 0.59$). Changes in average power output (APO) also approached significance ($p = 0.07$) (APO: EBTSIT: baseline = 508 ± 48, post = 530 ± 52 W; EBTAlone:

baseline = 532 ± 55, post = 533 ± 68 W). Neither group experienced any change in aerobic capacity ((Equation is included in full-text article.)or ventilatory threshold; $p \geq 0.16$). We conclude that replacing a portion of EBT with SIT can improve both 2,000-m erg performance and anaerobic capacity, while maintaining aerobic fitness in trained oarsmen. Incorporating SIT within endurance training programs may be useful during periods of low-volume training, to improve performance without sacrificing aerobic capacity.

Meckel Y, Harel U, Michaely Y, and Eliakim A. (2014) examined the effect of a very short-term training program on the immediate and late changes in the fitness level of young soccer players during the pre-season period. Twenty-four young (17-18 years) soccer players were randomly assigned to either an interval (9 to 5 X 1000 m) or continuous (9000 to 5000 m) training group, matched for total running distance. While the number of intervals or total distance was reduced every day, speed was increased in each session throughout the five days of both training programs. Each group performed 20 m shuttle run, 10 m sprint, 5 X 10 m run, 250 m run and vertical jump test, before (pre), immediately after (post) and 10 days after (late) completion of five successive training days during the preseason period for the upcoming soccer season. There was a significant increase in aerobic capacity both immediately post-training and in the late test, in both training groups. We found a significantly greater reduced performance in the 250 m run immediately following training in

the interval compared to the continuous training group. In addition, there was a decrease in vertical jump that was significantly greater in the interval compared to the continuous training group, both immediately post-training and in the late test. Very short interval or continuous preseason training programs induce significant improvement in aerobic fitness but lead to stagnation or deterioration in anaerobic performance. Considering the opposing effects of both training modes (positive on the aerobic power but negative on the anaerobic performance), coaches should make their choices based on the relevant conditions at hand.

Engel FA and Sperlich B. (2014) assessed the effect of the high intensity interval training(HIIT) on sport performance in healthy children and adolescents. Studies examining the effect of HIIT on aerobic and anaerobic performance pre and post to HIIT-Interventions in children and adolescents (9-18 years) were included. The results indicate increased aerobic and anaerobic performance following two or three HIIT sessions per week for a period of five to ten weeks, additional to normal training. Results regarding long term effects following HIIT have not been documented so far. In addition, due to the physiological characteris-tics during HIIT protocols improved fatigue resistance has been demonstrated in children as compared to adults, which may be interpreted as a prerequisite for the applicability of HIIT in children.

Hoffmann JJ Jr, Reed JP, Leiting K, Chiang CY, and Stone MH. (2014) documented that due to the broad spectrum of physical characteristics necessary for success in field sports, numerous training modalities have been used develop physical preparedness. Sports like rugby, basketball, lacrosse, and others require athletes to be not only strong and powerful but also aerobically fit and able to recover from high-intensity intermittent exercise. This provides coaches and sport scientists with a complex range of variables to consider when developing training programs. This can often lead to confusion and the misuse of training modalities, particularly in the development of aerobic and anaerobic conditioning. This review outlines the benefits and general adaptations to 3 commonly used and effective conditioning methods: high-intensity interval training, repeated-sprint training, and small-sided games. The goals and outcomes of these training methods are discussed, and practical implementations strategies for coaches and sport scientists are provided.

Carvalho HM, Coelho e Silva MJ, Figueiredo AJ, Gonçalves CE, Castagna C, Philippaerts RM, and Malina RM. (2011) evaluated the validity and reliability of the line-drill (LD) test of anaerobic performance in 76 male basketball players 14.0-16.0 years of age. The Wingate Anaerobic Test (WAnT) was used as the reference for anaerobic performance. Wingate Anaerobic Test and LD test were moderately correlated (0.39 and 0.43, $p < 0.01$). Estimated age at peak height velocity (APHV) was moderately, negatively, and significantly ($p <$

0.01) correlated with WAnT peak (r = -0.69) and mean power (r = -0.71); earlier-maturing players had greater anaerobic power. Training experience was not associated with anaerobic performance, but chronological age (CA) and estimated APHV were significant covariates of the LD test ($p < 0.05$). National players were better than local players on the LD test ($p < 0.01$) after controlling for CA and body size. Short-term reliability of the LD test (n = 12, 1-week interval) was good: technical error of measurement = 0.44 seconds (95% confidence interval [CI] 0.31-0.75 seconds), intraclass correlation coefficient = 0.91 (95% CI 0.68-0.97), and coefficient of variation = 1.4% (95% CI 1.0-2.3%). Although the relationship between the LD test and WAnT was moderate, the LD test effectively distinguished local- and national-level adolescent basketball players. In contrast to WAnT, the LD test was not influenced by estimated biological maturity status. Thus, the LD test may be suitable for field assessment of anaerobic performance of youth basketball players.

Hazell TJ, Macpherson RE, Gravelle BM, and Lemon PW. (2010) assessed whether 10-s sprint interval training (SIT) bouts with 2 or 4 min recovery periods can improve aerobic and anaerobic performance. Subjects (n = 48) were assigned to one of four groups [exercise time (s):recovery time (min)]: (1) 30:4, (2) 10:4, (3) 10:2 or (4) control (no training). Training was cycling 3 week(-1) for 2 weeks (starting with 4 bouts session(-1), increasing 1 bout every 2 sessions, 6 total). Pre- and post-training measures included: VO(2max), 5-km

time trial (TT), and a 30-s Wingate test. All groups were similar pre-training and the control group did not change over time. The 10-s groups trained at a higher intensity demonstrated by greater ($P < 0.05$) reproducibility of peak (10:4 = 96%; 10:2 = 95% vs. 30:4 = 89%), average (10:4 = 84%; 10:2 = 82% vs. 30:4 = 58%), and minimum power (10:4 = 73%; 10:2 = 69%; vs. 30:4 = 40%) within each session while the 30:4 group performed ~2X ($P < 0.05$) the total work session(-1) (83-124 kJ, 4-6 bouts) versus 10:4 (38-58 kJ); 10:2 (39-59 kJ). Training increased TT performance ($P < 0.05$) in the 30:4 (5.2%), 10:4 (3.5%), and 10:2 (3.0%) groups. VO(2max) increased in the 30:4 (9.3%) and 10:4 (9.2%), but not the 10:2 group. Wingate peak power kg(-1) increased ($P < 0.05$) in the 30:4 (9.5%), 10:4 (8.5%), and 10:2 (4.2%). Average Wingate power kg(-1) increased ($P < 0.05$) in the 30:4 (12.1%) and 10:4 (6.5%) groups. These data indicate that 10-s (with either 2 or 4 min recovery) and 30-s SIT bouts are effective for increasinganaerobic and aerobic performance.

2.3 STUDIES ON TRAINING EFFECTS ON PHYSICAL VARIABLES

Padulo J, Tabben M, Ardigò LP, Ionel M, Popa C, Gevat C, Zagatto AM, and Dello Iacono A. (2015) described the influence of recovery duration during a repeated sprint ability (RSA) test (6×40 m) by investigating a number of variables, such as general performance, metabolic demand, and muscular stretch-shortening performance. Seventeen male soccer outfield players (16 ± 0 years, 66 ± 10 kg) performed three field shuttle-running tests with 15, 20, and 25-sec

recoveries. In addition to specific shuttle test's variables, blood lactate concentration and vertical jump height were assessed. Resulting measures were highly reliable (intra-class correlation coefficient up to 0.86). 25-sec recovery improved test performance (-3% total time from 15-sec to 25-sec recovery), vertical jump height (+7% post-test height from 15-sec to 25-sec recovery), and decreased blood lactate accumulation (-33% post-test from 15-sec to 25-sec recovery). Study findings suggest that metabolic acidosis plays a role in worsening performance and fatigue development during the shuttle test. A 25-sec recovery duration maximized performance, containing metabolic-anaerobic power involvement and muscular stretch-shortening performance deterioration during a RSA test.

Patterson C et al. (2014), tested the reproducibility of the 2.5 min loaded repeated jump test (LRJT) and to test the effectiveness of general preparation period (GPP) training on anaerobic fitness of elite alpine ski racers with the LRJT. Thirteen male volunteers completed 2 LRJTs to examine reliability. Nine male Austrian elite junior racers were tested in June and October 2009. The LRJT consisted of 60 loaded countermovement jumps (LCMJs) with a loaded barbell equivalent to 40% bodyweight. Prior to the LRJT the power (P) of a single LCMJ was determined. P was calculated from ground reaction forces. The mean P was calculated for the complete test and for each 30 s interval. The interclass correlation coefficients (between 0.88 and 0.99) for main variables of the LRJT

demonstrated a high reliability. A repeated measures ANOVA indicated thatanaerobic capacity was significantly higher in October ($p < 0.05$). The ski racers' single LCMJ P increased from 37.0 ± 1.2 to 39.0 ± 1.4 W.kg. The mean P of the total test improved from 33.6 ± 1.2 to 35.8 ± 1.3 W.kg, but relative effect of fatigue did not change. The GPP training improved the athletes' ability to produce and maintain muscular power. The LRJT is a reliable anaerobic test suitable for all alpine ski racing events because the 60 jumps simulate the approximate number of gates in slalom and giant slalom races and the 2.5 min is equivalent to the duration of the longest downhill race.

Kuni B et al. (2014) analyzed the influence of fatigue on dynamic postural control in jump landing and stabilization in athletes of different levels.In all, 18 high-performance ball sports athletes and 24 recreationally active subjects performed a jump test before and at 1, 5, 10, 15, and 20 min after a 30-min treadmill run at the individual anaerobic threshold. An overhead ball switch hit during a forward jump triggered indicator lamps on either side of a force plate. After landing on the plate, stabilization on one leg (no light cue) or a second jump sideways (towards a light cue) was required. The stabilization force integral index was calculated for the stabilization trials.Dynamic postural control was significantly impaired in jump landing and stabilization in the first minute after the run: mean difference +/- standard deviation: 0.25 +/- 0.48m/s (95% confidence interval: 0.10-0.40 m/s, p=0.043; ANOVA). No significant group

differences were found.Under fatigued conditions, dynamic postural control in jump landing was impaired in an unexpected stabilization task. Not only recreational, but also high-performance athletes were affected. Ball sports athletes could add a training exercise to their workout which alternates between periods of high effort and neuromuscular training. Resistance to fatigue effects should be checked on a regular basis using jump tests

Theodorou A, Paradisis G, Panoutsakopoulos V, Smpokos E, Skordilis E, and Cooke CB. (2013) assessed the validity of jump height (h), absolute (VPOWERABS) and relative to body mass (VPOWERREL) performance indices when elicited of a modified 30 s Bosco vertical jump test (VJT) based on the absolute (WPOWERABS) and relative (WPOWERREL) power values of a 30 s Wingate test (WAnT). Methods: Nineteen physical education students with mean ± SD age 21±3 y, body mass 73.8±7 kg and height 1.8±0.06 m performed a 30 s VJT on a force plate and a 30 s WAnT on a Monark cycle ergometer. Performance data were expressed in W and W.kg-1 of body mass for WPOWERABS and WPOWERREL; in cm, W and W.kg-1 for h, VPOWERABS and VPOWERREL, respectively. The performance indices' values were expressed as means and SDs of the 30 s duration of both tests, as well as in 4 time intervals of 7.5 s (0-7.5 s, 7.5-15 s, 15-22.5 s, and 22.5-30 s). Results: WPOWERABS and h were significantly ($P<0.05$) correlated in the 4 time intervals (0-7.5 s: $r=0.51$; 7.5-15 s: $r=0.36$; 15-22.5 s: $r=0.39$) and in the overall duration of the test (0-30 s:

r=0.38). Significant correlation was also revealed between VPOWERABS and WPOWERABS, but only for the interval 0-7.5 s (r=0.48). Conclusion: A 30 s VJT is valid against a 30 s WAnT only when h is used as performance indices. The selection of the appropriate unit of measurement is important for assessing effort distribution in maximum effort tests of short duration.

William (2003) conducted a study on children's and adolescents anaerobic performance during cycle ergometry. The anaerobic test friction braked wingate, other tests such as the fork velocity and isokinetic cycle ergometers were becoming more common. There was unequivocal agreement that children's and adolescence anaerobic power scores were lower than those of adults. Qualitative muscular differences were often cited for this disparity rather than difference in the quantity of the muscle, but conclusive research was lacking in this area.

Bacharach and Davillard (2004) examined a study of intermediate and a long term anaerobic performance of elite Alpine skiers. Many researchers identified that Alpine skiers need muscular strength and complex motor skill abilities. After verifying a variety of tests short test of anaerobic capacity came into existence. Seventeen Nationality ranked male and female Alpine Ski racers from USA were used. The power was measured in them by keeping 30.5 and 90.5 wingate cycle ergometry tests. Through this study they found that capacity of anaerobic power can be altered.

Bal (2015) made an attempt to assess the effects of a short term plyometric training program of agility in young basketball players. A group of Thirty (N=30) male inter collegiate basketball players aged 18–24 years. Their mean height, weight, and age were 1.87±0.06m, 75.5± 5.2kg, 22.5± 0.4 years. The subjects were randomly assigned into two groups: experimental (E; n=15) and control (C; n=15). Group E was subjected to a 6-week training. The results of the study reveal that the short term plyometric training program improved agility and strength in young basketball players.

Manoj and Thirumalai (2015) conducted a study to find out the effect of specified football drills with and without relaxation techniques on selected game skill variables among school level football players. The dribbling ability Morgan Christian soccer ability test was used, it was measured in seconds and it was a standardized test. The result of the study revealed that both the experimental training namely specified football drills with relaxation technique and specified football drills without relaxation technique had significant improvement on selected skill variables namely passing, shooting and dribbling among the school level football players. There is no significant difference on the improvement of selected skill variables between both experimental groups among the school level football players.

Manna (2016) conducted a study to find out the training induced changes on different physiological and biochemical parameters in young Indian soccer

players. A total of 30 Indian male soccer players (age range 14-16 years) regularly playing competitive soccer were selected, a training programme consist of 6 weeks and 12 weeks of training was employed, and the effects were studied on different morphological, physiological and biochemical variables. The result of the study showed a significant decrease ($P<0.05$) in body fat. Strength of back and hand grip muscles were also increased significantly ($P<0.05$) after the training. Moreover, significant reduction in heart rates during rest, sub-maximal exercise, maximal exercise and recovery were noted following the training. Further, significant increase ($P<0.05$) in aerobic capacity and anaerobic power were observed after the training.

Initha (2015) examined the effect of aerobic exercises and psychological training on selected physical and psychological variables among college women football players. 45 college level women football players were selected from Chennai colleges as subjects. They were divided into three equal groups' namely, experimental group I, experimental group II and control group III. Each group consists of 15 players. Experimental group I underwent aerobic exercises, experimental group II underwent psychology training and group three acted as control group for the 12 weeks period. Before and after the experimental the pre and post-test was conducted for speed, cardiovascular endurance, anxiety and stress management. The result of the study indicated that the aerobic exercises

and psychological training speed, cardiovascular endurance, stress management and anxiety were significantly improved.

Manohar (2015) made study to investigate whether additional circuit training will be of any benefit in improving the performance of the students undergoing training in the following events Cardiovascular Endurance, Vertical Jumping Ability, Agility and Muscular Endurance. 40 students were selected at random and were divided in two groups of 20 each by random allotment one of the groups was treated as control group. Experimental group followed specifically prescribed circuit training scheduled three days a week for period of eight weeks. Final readings in the criterion measures were taken. The result of the study showed significant improvement in selected criterion variables due to the effect of continuous circuit training

Haghighi (2015) conducted a study to investigate the effect of plyometric versus resistance training (PT vs. RT) on sprint and skill performance in young soccer players. Thirty elite soccer players participated in this study as the subject. The subjects were randomly assigned to PT group (n=10, age: 19.1±1.7 years), RT group (n=10, age: 18.0± 0.81) or control group (n=10, age: 18.8±1.5 years). The result of the study showed that the time of sprint running test and dribbling improve after PT and RT ($P<0.05$). For accuracy of shooting no significant change was observed after 8weeks PT and RT.

Raj Kumar (2015) examined the effect of 6 week plyometric training program on agility of collegiate soccer players. To achieve the purpose of these study 30 students was selected as subjects. Their age ranged between 20 to 25 years. The selected subjects were randomly divided into two groups each group consists of 15 students, namely experimental group and control group. Polymeric training for 6 week was assigned to experimental group; experimental group and control group does not undergone any type of experimental training. All the training programmes were scheduled for three days per week for a period of 6 week. The result of the study shows that there was significant effect of 6 week polymeric training group agility of collegiate soccer players. This meta-analysis extends that the plyometric training improved times in the agility measures because of either better motor recruitment or neural adaptations.

Helgerud and Engen (2015) conducted a study to determine the effects of aerobic training on performance during soccer match and soccer specific tests. Nineteen male elite junior soccer players, age 18.1=0.8 year, randomly assigned to the training group (N=9) and the control group (N=10) participated in the study. The specific aerobic training consisted of interval training, four times 4-min at 90–95% of maximal heart rate, with a 3-min jog in between; twice per week for 8 wk. Players were monitored by video during two matches, one before and one after training. The result of the study shows that aerobic endurance training in soccer players improved soccer performance by increasing the distance

covered, enhancing work intensity, and increasing the number of sprints and involvement with the ball during a match.

Dupont (2015) conducted a study in-season, high-intensity interval training on professional male soccer players' running performances were investigated. Twenty-two subjects participated in 2 consecutive training periods of 10 weeks. The first period was considered a control period and was compared with a period where 2 high-intensity interval training exercises were included in the usual training program. Intermittent runs consisted of 12-15 runs lasting 15 seconds at 120% of maximal aerobic speed alternated with 15 seconds of rest. Sprint repetitions consisted of 12-15 all-out 40-m runs alternated with 30 seconds of rest. The result of the study reveals that high-intensity interval training have shown that maximal aerobic speed was improved (+8.1 +/- 3.1%; $p < 0.001$) and that the time of the 40-m sprint was decreased (-3.5 +/- 1.5%; $p < 0.001$), whereas no change in either parameters were observed during the control period.

Sedano (2015) the main aim of this study was to determine the effects of a 10-week plyometric training program on explosive strength, acceleration capacity and kicking speed in young elite soccer players. Twenty-two players participated in the study: control group (CG), (N=11; 18.2±0.9 years) and treatment group (TG) (N.=11; 18.4±1.1 years). The result of the study revealed that a 10-week plyometric program may be an effective training stimulus to improve explosive strength compared to a more conventional physical training

program. The improvements in explosive strength can be transferred to acceleration capacity and kicking speed but players need time to transfer these.

VenuGopal and Anbalagan (2015) examined the effects of Pilates training and yogic training with and without combinations on selected physical fitness components among college level obese student. Eighty male obese students for this study were selected from Bishop Ambrose College, Coimbatore randomly and divided into four groups as three experimental and control groups. Data were collected from each subject before and after the training. The result of the study found that there was significant reduces on percent body fat and significant improvement in flexibility of experimental groups when compared to the control group.

Aguiar and Abrantes (2016) conducted a study to find out the effect of two different training interventions (Intermittent versus Continuous training) on semi-professional male soccer player's speed, jump and repeated-sprint ability. Thirty four players were divided into an intermittent training group (INT, n=18, age=26.7±4.7, height=175.3±5.2cm, weight=72.9±4.8Kg) and a continuous training group (CONT, n=16, age=26.6±5.1, height=174.9±5.9 cm, weight=73.2±7.2 Kg). The study lasted for 12 weeks and consisted of 20 minutes per training session in physical conditioning following either CONT or INT training guidelines. The players were tested 3 times during 1st, 6th and 12th week of the season. Testing consisted of 15 m and 30 m sprint time, squat-jump and

counter movement jump height and Bangsbo modified sprint test. The result of the study showed that INT was faster than CONT in the 6th and 12th weeks for the squat jump, 15 m, 30 m and Bangsbo Modified Sprint Test and that INT recovered better from intense efforts than control group.

Aguiar, et al, (2016) compared the effect of two different training interventions (Intermittent versus Continuous training) on semi-professional male soccer player's speed, jump and repeated-sprint ability. Thirty four players were divided into an intermittent training group (INT, n=18, age=26.7±4.7, height=175.3±5.2cm, weight=72.9±4.8Kg) and a continuous training group (CONT, n=16, age=26.6±5.1, height=174.9±5.9cm, weight=73.2±7.2Kg). The study lasted for 12 weeks and consisted of 20 minutes per training session in physical conditioning following either CONT or INT training guidelines. The players were tested 3 times during 1st, 6th and 12th week of the season. Testing consisted of 15m and 30m sprint time, squat-jump and countermovement jump height and Bangsbo modified sprint test. Two-way repeated measures ANCOVA (group: INT, CONT x TIME-POINT: Week1, Week6, Week12) showed that INT was faster than CONT in the 6th and 12th weeks for the squat jump, 15m, 30m and Bangsbo Modified Sprint Test and that INT recovered better from intense efforts than CONT. The results suggested that both training interventions were able to maintain initial values of speed and jump. However, the INT exhibited larger improvements in repeated-sprint ability. Therefore, the power endurance

training (intermittent high intensity exercise) might be more beneficial to prepare soccer players according to the game cardiovascular and metabolic specific determinants.

2.4 STUDIES ON TRAINING EFFECTS ON PHYSIOLOGICAL VARIABLES

Mughal (2015) examined the effects of aerobic exercise, on changes in blood pressure, in patients with essential hypertension. A 12-weeks aerobic exercise intervention trial was conducted, to examine the influence of brisk walking on resting systolic and diastolic blood pressure, pulse pressure, mean arterial blood pressure, body weight and body mass index in patients with essential hypertension. The aerobic exercise training protocol consisted of 30 minutes of brisk walking 3 to 5 times per week, at 50% of VO2max on an ergo meter cycle. The result of the study showed significant decrease in resting systolic and diastolic blood pressure were found ($p<0.05$). Reduced pulse pressure from baseline value and mean arterial pressure was noted. No discernible effects on mean body mass index was observed although mean body weights decreased. Brisk walking yielded significant increase in VO2max ($p<0.05$). Aerobic exercise caused small reduction in resting systolic and diastolic blood pressures in men.

Astorino et al. (2015) studied effect of HIIT on cardiovascular function, VO2max, and muscular force over 6 sessions of HIIT in a span of 2-3 weeks in 20 young, healthy adult men and women. The authors found significant improvement

in VO2max. No change was noticed in resting blood pressure, heart rate or force production

Astorino and Allen (2016) conducted a study to examine the effects of short-term high-intensity interval training (HIIT) on cardiovascular function, cardio respiratory fitness, and muscular force. Active, young (age and body fat = 25.3±4.5 years and 14.3±6.4%) men and women (N=20) of a similar age, physical activity, and maximal oxygen uptake (VO2max) completed 6 sessions of HIIT consisting of repeated Wingate tests over a 2 to 3-week period. Subjects completed 4 Wingate tests on days 1 and 2, 5 on days 3 and 4, and 6 on days 5. A control group of 9 men and women (age and body fat = 22.8±2.8 years and 15.2±6.9%) completed all testing but did not perform HIIT. The result of the study reveals that Changes in resting blood pressure (BP) and heart rate (HR), VO2max, body composition, oxygen (O2) pulse, peak, mean, and minimum power output, fatigue index, and voluntary force production of the knee flexors and extensors were examined pre training and post training.

Cregg and Cathal (2016) conducted a study to determine the effect of high intensity interval training (HIIT) and high volume endurance training (HVET) on indices of endurance, speed and power in male Gaelic football players. Club level Gaelic football players (n=25) ranging from 18 to 35 years of age were randomly assigned to a HIIT (mean ± SD; 27.2±3.6 years) or a HVET (mean ± SD 24.7±4.0 years) group. The result of the study reveal that Maximal

aerobic capacity increased significantly in both the HIIT and HVET group in response to the 6 week training program, and the percentage improvement was similar (7%) in both groups. There was no change in CMJ, CMJ flight time or 5 m speed in either group in response to training. Compared to baseline, performance in the VJ and 20 m sprint decreased significantly in the HVET group following the 6 week training program, and did not change in the HIIT group.

Robert Clive et al., (2016) conducted a study to determine the effect of interval training on purpose forty five (n=45) male students were selected as subjects and their age group ranged between 18 and 22 years. They were divided into three equal groups, each group consisted of fifteen (n=15) subjects. The group I underwent training (PTG), group II underwent interval training and group III act as control (CG) which did not curriculum. The training period for this study was three days in a week for twelve weeks. The results of the study reveal that vital capacity was significantly improved by plyometric training group and Interval training group.

Sheykhlouvand M, Bishop P, Khalili E, Agha-Alinejad H, and Gharaat M. (2015) compared the effects of two different high-intensity interval training (HIIT) programs in professional male canoe polo athletes. Responses of peak oxygen uptake (VO2peak), ventilatory threshold (VT), peak and mean anaerobic power (PPO & MPO), blood volume, and hormonal adaptations to HIIT were examined. Male athletes (n=21, age: 24 ± 3

years; height : 181 ± 4 cm; mass: 85 ± 6 kg and Body fat: 12.9 ± 2.7%) were randomly assigned to one of three groups (N=7): 1) (G1) interval paddling with variable volume (6,7,8,9,9,9,8,7,6 repetitions/session from 1 to 9 session respectively) × 60-second at lowest velocity that elicited VO2peak (vVO2peak), 1:3 work to recovery ratio); 2) (G2) interval paddling with variable intensity (6 × 60-second at 100,110,120,130,130, 130,120,110,100% vVO2peak from 1 to 9 session respectively, 1:3 work to recovery); and 3) (GCON) the control group performed three 60 min paddling sessions (75% vV O2peak) per week for 3 weeks. High-intensity interval training resulted in significant (except as shown) increases compared with pretest, in: VO2peak (G1=+8.8%, G2=+8.5%), heart rate at VT (b.min) (G1=+9.7%, G2=+5.9%) and (%maximum) (G1=+6.9%; P=0.29, G2=+6.5%), PPO (G1=+9.7%, G2=+12.2%), MPO (G1=+11.1%; P=0.29, G2=+16.2%), total testosterone (G1=+29.4%, G2=+16.7%), total testosterone/cortisol ratio (G1=+40.9%, G2=+28.1%), and mean corpuscular hemoglobin (G1=+1.7%, G2=+1.3%). No significant changes were found in GCON. High-intensity interval paddling may improve both aerobic and anaerobic performances in professional male canoe polo athletes under the conditions of this study.

Astorino TA, Schubert MM, Palumbo E, Stirling D, McMillan DW, Gallant R, and Dewoskin R. (2015) examined acute and chronic changes in perceptual measures (rating of perceived exertion (RPE), affect, and arousal) in

response to two regimens of high intensity interval training (HIIT). Twenty three healthy sedentary women (mean ± SD age and VO2max = 23.0 ± 5.7 yr and 30.1 ± 4.4 mL.kg.-1.min-1, respectively) were randomized to complete 12 wks of one of two HIIT regimes, while an additional seven women served as sedentary controls. Training was performed 3 d.wk-1 on a cycle ergometer and consisted of up to ten 1 min bouts at moderate (60 - 80 %Wmax = MOD) or more intense (80 - 90 %Wmax = HI) workloads separated by active recovery. At baseline and every 3 wks, RPE, affect, and arousal were measured during training using validated scales. Repeated measures analysis of variance was used to examine acute and chronic changes in these variables to HIIT. Data revealed significant ($p < 0.001$) increases in RPE and arousal and decreases ($p < 0.001$) in affect during acute HIIT, with RPE responses differing ($p < 0.05$) between HI and MOD. However, acute changes in affect and arousal were similar in HI and MOD. Training led to a significant reduction in RPE; whereas, both affect and arousal were unchanged ($p > 0.05$) after HIIT. Completion of moderate or more intense interval training reduces perceptions of RPE during training, yet does not alter arousal or affect. RPE was reduced via training, yet large dependence upon anaerobic metabolism during HIIT may minimize training-induced changes in affect.

Chan-Dewar F, Kong Z, Shi Q, et al. Nie J (2015) assessed effects of two different volumes of sprint-interval cycling on post-prandial blood glucose.

Twenty healthy young males undertook two Wingate anaerobic tests (2WAT), four Wingateanaerobic (4WAT) and without-exercise (CON) 90min after eating a standard meal. Blood glucose was examined at 60, 90, 105, 120, 135 and 150min post-prandially. 2WAT and 4WAT both accelerated the decrease of blood glucose compared with CON ($P<0.05$). There were significant reductions at 120 (4.45±0.64 vs. 4.93±0.9 vs. 5.68±0.69), 135 (4.28±0.50 vs. 4.48±0.75 vs. 5.54±0.6) and 150min (4.64±0.71 vs. 4.71±0.73 vs. 5.36±0.48, all $P<0.05$). Blood glucose at 120min was lower after 2WAT than 4WAT (4.45±0.64 vs. 4.93±0.9, $P<0.05$), this producing a significant statistical interaction between groups and post-exercise time ($P<0.005$). 2WAT and 4WAT tests both accelerate the post-prandial decrease in blood glucose in young healthy males, 2WAT being superior to 4WAT in producing this response, even though 2WAT is easier to perform and less time consuming.

Nalcakan GR (2014) compared the effects of sprint interval training (SIT) and continuous endurance training (CET) on selected anthropometric, aerobic, and anaerobic performance indices as well as the blood lipid profile, inflammatory and muscle damage markers in healthy young males. Fifteen recreationally active male volunteers (age: 21.7 ±2.2 years, body mass: 83.0 ±8.0 kg, body height: 1.82 ±0.05 m) were divided into two groups according to their initial VO2max levels. Training programs were conducted 3 times per week for 7 weeks. The SIT program consisted of 4-6 Wingate anaerobic sprints with a 4.5

min recovery, while CET consisted of 30-50 min cycling at 60% VO2max. Biochemical, anthropometric and fitness assessments were performed both pre and post-intervention. Significant improvements in VO2max, anaerobic power and capacity, and VO2 utilization during the submaximal workout and significant decreases in body fat and in waist circumference after the intervention occurred in both SIT and CET groups. Significantly greater gross efficiency was measured in the CET group. No differences in the lipid profile or serum levels of inflammatory, myocardial and skeletal muscle damage markers were observed after the training period. The study results agree with the effectiveness of a 30 s all-out training program with a reduced time commitment for anthropometric, aerobic and anaerobic adaptation and eliminate doubts about its safety as a model.

Mueller SM, Aguayo D, Zuercher M[1], Fleischmann O, Boutellier U, Auer M, Jung HH, and Toigo M. (2015) examined whether side-alternating whole-body vibration as a replacement for the active rest intervals during a 4 x 4 min HIT prevents decreases in anaerobic performance and capacity without compromising gains in aerobic function. Thirty-three young recreationally active men were randomly assigned to conduct either conventional 4 x 4 min HIT, HIT with 3 min of WBV at 18 Hz (HIT+VIB18) or 30 Hz (HIT+VIB30) in lieu of conventional rest intervals, or WBV at 30 Hz (VIB30). Pre and post training, critical power (CP), W', cellular muscle characteristics, as well as cardiovascular and neuromuscular variables were determined. W' (-14.3%, P = 0.013), maximal

voluntary torque (-8.6%, P = 0.001), rate of force development (-10.5%, P = 0.018), maximal jumping power (-6.3%, P = 0.007) and cross-sectional areas of MyHC-2A fibers (-6.4%, P = 0.044) were reduced only after conventional HIT. CP, VO2peak, peak cardiac output, and overall capillary-to-fiber ratio were increased after HIT, HIT+VIB18, and HIT+VIB30 without differences between groups. HIT-specific reductions in anaerobic performance and capacity were prevented by replacing active rest intervals with side-alternating whole-body vibration, notably without compromising aerobic adaptations. Therefore, competitive cyclists (and potentially other endurance-oriented athletes) may benefit from replacing the active rest intervals during aerobic HIT with side-alternating whole-body vibration.

Scribbans TD et al. (2014) involved the completion of two distinct experiments. Experiment 1 compared fibre specific and whole muscle responses to acute bouts of either low-volume high-intensity interval training (LV-HIT) or moderate-intensity continuous endurance exercise (END) in a randomized crossover design. Experiment 2 examined the impact of a six-week training intervention (END or LV-HIT; 4 days/week), on whole body and skeletal muscle fibre specific markers of aerobic and anaerobic capacity. Six recreationally active men (Age: 20.7±3.8 yrs; VO2peak: 51.9±5.1 mL/kg/min) reported to the lab on two separate occasions for experiment 1. Following a muscle biopsy taken in a fasted state, participants completed an acute bout of each exercise protocol (LV-HIT: 8, 20-second

intervals at □170% of VO2peak separated by 10 seconds of rest; END: 30 minutes at □65% of VO2peak), immediately followed by a muscle biopsy. Glycogen content of type I and IIA fibres was significantly ($p<0.05$) reduced, while p-ACC was significantly increased ($p<0.05$) following both protocols. Nineteen recreationally active males (n=16) and females (n=3) were VO2peak-matched and assigned to either the LV-HIT (n=10; 21±2 yrs) or END (n=9; 20.7±3.8 yrs) group for experiment 2. After 6 weeks, both training protocols induced comparable increases in aerobic capacity (END: Pre: 48.3±6.0, Mid: 51.8±6.0, Post: 55.0±6.3 mL/kg/min LV-HIT: Pre: 47.9±8.1, Mid: 50.4±7.4, Post: 54.7±7.6 mL/kg/min), fibre-type specific oxidative and glycolytic capacity, glycogen and IMTG stores, and whole-muscle capillary density. Interestingly, only LV-HIT induced greater improvements in anaerobic performance and estimated whole-muscle glycolytic capacity. These results suggest that 30 minutes of END exercise at □65% VO2peak or 4 minutes of LV-HIT at □170% VO2peak induce comparable changes in the intra-myocellular environment (glycogen content and signaling activation); correspondingly, training-induced adaptations resulting for these protocols, and other HIT and END protocols are strikingly similar.

2.5 STUDIES ON TRAINING EFFECTS ON BIOCHEMICAL VARIABLES

Thomas et al, (2015) examined the effect of interval and continuous exercise programs on plasma lipoproteins, apoproteins, and lecithin: cholesterol acyltransferase (LCAT). Thirty-six college male students (age 18-25 yrs.) were randomly assigned to a 5 mile continuous exercise group, 4 minute interval (1:1, work: rest), 2 minute interval (1:1-1/2, work: rest), or control. Workloads were equated by kcal expenditure/workout. The training groups exercised for one hour three times a week for 11 weeks. Neither interval nor continuous exercise programs significantly altered plasma total cholesterol, high density lipoprotein cholesterol (HDL-C), apoprotein A-1 (Apo A-1), apoprotein B (Apo B), or LCAT. Posttest maximal oxygen consumption was significantly higher than pretest for the 4 minute interval and 5 mile continuous groups. Thus continuous exercise and long interval programs resulted in gains in aerobic capacity, but none of the training programs were effective in altering the plasma lipoproteins or apoproteins investigated.

Dongsheng and Haipeng (2016) investigated the effects of aerobic exercise on blood pressure, lipid metabolism and the relation of BMI and both blood pressure and lipid metabolism. Eight obese adolescents (four boys and four girls, 13.88±1.96 years, BMI is 33.27±5.63) performed aerobic exercise five times per week over 6 weeks period at an intensity of approximately 75% of HRmax.

After 6 weeks of aerobic exercise the result of the study reveals that BMI went from 33.27±5.63 to 30.07±5.30 ($p<0.01$), the content of HDL went from 1.39±0.15 to 1.27±0.16 ($p>0.05$), the content of LDL went from 2.86±0.44 to 2.12±0.26 ($p<0.01$), the total cholesterol level went from 5.08±0.70 mmol/l to 4.10±0.36 mmol/l ($p<0.05$), the systolic blood pressure went from 119.50±8.40 mm Hg to 108.0 ±18.46 Hg ($p<0.01$), the diastolic blood pressure went from 79.75±12.76 mm Hg to 65.75±12.12 mm Hg ($p<0.05$). Aerobic exercise improves blood pressure and is associated with reduced BMI in obese adolescents.

Moreira MM, Souza HP, Schwingel PA, Sá CK, and Zoppi CC. (2008) compared the effects of aerobic and anaerobic exercise protocols on cardiac risk factors. 22 individuals with mean age of 40+/-8 years were distributed into the following groups: control (CO),endurance training (ET) and interval training (IT). The protocols lasted 12 weeks, three times a week, with intensities of 10% below and 20% above the anaerobic threshold (AnT). The following measurements were taken: total body mass (TBM), body mass index (BMI), waist circumference (WC), hip circumference (HC), and body composition, in addition to plasma concentrations of glucose (GLU), total cholesterol (CHO), and triglycerides (TG). Waist-hip ratio (WHR) and conicity index (C index) were also calculated. The TBM, BMI, WC, GLU, and body composition variables showed significant changes in the ET and IT groups. CHO and HC values were significantly reduced in the ET group, whereas WHR showed a significant reduction in the IT group.

AnT and C index in the IT group were significantly different in relation to ET.In view of the differences found in the results of the variables studied in relation to the trainingperformed, we conclude that an exercise program that includes both high and low-intensity activities is more efficient to ensure the reduction of a greater number of cardiac risk variables.

Hussein S et.al (2008) to evaluate the quality of the Continuous training a total of 9 subjects were investigated during free floor walking and stair climbing and during free floor walking and stair climbing and during the same tasks in two different Continuous training modes on the HapticWalker: 1) with and 2) without vertical center of mass (CoM) motion. Electromyograms (EMG) of 8 gait relevant muscles were measured and muscle activation was compared for the various training modes. Besides the muscle activation as an indicator for the quality of rehabilitation training the study investigates if a cancellation of the vertical movement by adoption of the footplate trajectory is feasible i.e. the muscle activation patterns for the two training modes on the Haptic Walker agree. Results show no significant differences in activation timing between the training modes. This indicates the feasibility of using a passive patient suspension and emulates the vertical motion by trajectory adoption of the footplates. The muscle activation timing duringHaptic Walker training shows important characteristics observed in physiological free walking though a few differences can still remain.

Lockwood KL, Frost G. (2007) conducted a study on assessed changes in selected physiological and kinematic variables over 6 weeks of treadmill skating in an effort to understand the process of habituation to this Continuous training modality. Seven male, Atom-A hockey players who were injury-free and had no previous treadmill skating experience participated in the study. Players performed four 1-min skating bouts at progressively increasing speeds, each week, for 6 weeks. One speed (10.5 km/h) was repeated weekly to allow for assessment of the habituation process. Our criteria for habituation were: a decrease in stride rate, heart rate and rating of perceived exertion, and an increase in stride length, trunk angle and vertical movement of the centre of mass, leading to a plateau, over the course of the 6-week study. Significant decreases were seen in stride rate, heart rate and ratings of perceived exertion, and significant increases were found in stride length. Some of these changes were evident after only one week of Continuous training and all were present by week 4. After 6 weeks (24 min) of exposure to treadmill skating, all participants displayed a visibly more efficient skating style.

Roef, et al. (2002) studied the role of lactate in gluconeogenesis during exercise in untrained fasting humans. They concluded that lactate infusion during low-intensity exercise in fasting humans (1) increased gluconeogenesis from lactate, and (2) increased glucose production, thus increasing the blood glucose concentration. These results indicate that gluconeogenesis capacity is available in

humans after an overnight fast and can be used to sustain blood glucose levels during low intensity exercise when lactate, a known precursor of gluconeogenesis, is available at elevated plasma levels.

Haluzikova, et al. (2000) made a study to follow the influence of the regular hard physical training on the serum leptin levels. Therefore, the serum leptin levels in top rugby players, top race walkers and age and gender matched control group were compared. The relationship between serum leptin concentrations and body mass index and body fat content was also studied. It was found that serum leptin levels in rugby players were significantly higher than in race walkers group, but lower than in control one. Serum leptin levels in race walkers group, but lower than in control one. Serum leptin levels in race walkers were lower than those of rugby players and of control group. The body fat content in race walkers was lower than resting two groups. There was no significant difference in body fat content between control and rugby players group. Serum leptin levels correlated positively with body mass index and body fat content both in control and in rugby players group. No statistically significant relationship was found between leptin and body mass index or body fat content respectively in race walkers group. It was concluded that serum leptin levels in top sportsmen are lower than in non-sporting healthy age and gender matched controls. The lower leptin levels in top sportsmen are probably in part the result

of lower body fat content and in part the result of complex neurohormonal adaptation on the long term physical training.

2.5 STUDIES ON TRAINING EFFECTS ON BIOCHEMICAL VARIABLES

Elferink-Gemser MT, et. Al (2006) conducted a study on gain more insight into the mechanisms that underlie the development of interval endurance capacity in talented youth field hockey players in the 12-19 age band. A total of 377 measurements were taken over three years. A longitudinal model for interval endurance capacity was developed using the multilevel modellingprogram . With the model, scores on the interval shuttle run test can be predicted for elite and sub-elite male and female field hockey players aged 12-19 years. A polynomial model of order 2 adequately represents development of the test scores over time. The fixed part of the model contains a different intercept and linear age term for boys and girls, and a common quadratic term; the random part of the model has a common level 2 variance and sex specific level 1 variances. The model was significantly improved by including differential effects of performance level for age and sex. A negative effect was found for percentage body fat, and positive effects for Continuous training and motivation. During adolescence, both male and female elite hockey players show a more promising development pattern of

interval endurance capacity than sub-elite youth players. Percentage body fat, Continuous training hours, and motivation influence this development. However, differences between the individual players are still considerable.

Maedler, et al. (2002) studied the effect of saturated and monounsaturated fatty acids at different glucose concentrations on human beta-cell turnover and secretory function. Exposure of cultured human islets to saturated fatty acid and/or to an elevated glucose concentration for 4 days increased beta-cell DNA fragmentation and decreased beta-cell proliferation. In contrast, the monounsaturated palmitoleic acid or oleic acid did not affect DNA fragmentation and induced beta-cell proliferation. Moreover, each monounsaturated fatty acid prevented the deleterious effects of both palmitic acid and high glucose concentration. The cell-permeable ceramide analogue C(2)-ceramide mimicked both the palmitic acid-induced beta-cell apoptosis and decrease in proliferation. Finally, each monounsaturated fatty acid improved beta-cell secretory function that was reduced by palmitic acid and by high glucose. Thus, in human islets, the saturated palmitic acid and elevated glucose concentration induce beta-cell apoptosis, decrease beta-cell proliferation, and impair beta-cell function, which can be prevented by monounsaturated fatty acids. The deleterious effect of palmitic acid is mediated via formation of ceramide and activation of the apoptotic mitochondrial pathway.

In a study by Hung, et al. (2003) summarized lower cholesterol and postprandial blood glucose results are associated with viscous fibers. Diets that are higher in monounsaturated fatty acids, fiber and low glycemic index foods appear to have advantages in insulin resistance, glycemic control and blood lipids in a number of studies. The division of nutrients into total fat (regardless of fatty acids) versus carbohydrate (type and quantity not specified) appears to be less helpful in predicting outcomes.

2.6 SUMMARY OF RELATED LITERATURE

The investigator reviewed related literature on continuous training, interval training, training effects on physical variables, training effects on physiological variables and training effects on biochemical variables pertaining to this study. Researches reviewed proved that though these studies were conducted among different groups of people, there is further scope for research to find out the effects of continuous training and interval training on selected physical, physiological and biochemical variables of college level boxers. Hence, this research was attempted.

Based on the experience gained through review of related studies, the investigator formulated suitable methodology to be adopted in this research which is presented in Chapter III.