CHAPTER – II

REVIEW OF RELATED LITERATURE

The review of literature related to the problem has been presented in this Chapter. The working bibliography was collected from the libraries of the Annamalai University, Annamalai Nagar, Alagappa University, Karaikudi, and the Sports Authority of India, Nethaji Subash National Institute of Sports, Bangalore. The researcher also collected related information from the Internet.

Interval training theory is based on fixed-intensity work. However, in practical situations, work levels range extensively. Investigation measured physiological responses to varied intensity interval training. Runners (M = 9; F = 3), after initial testing, performed four interval training conditions of 24 x 1, 12 x 2, 6 x 4, or 4 x 6 minute bouts with equal work and rest durations, resulting in a total of 48 minutes of involvement for each condition. Average running velocity decreased with increase in interval duration. Peak VO2 was significantly higher for 2, 4, and
6 minute intervals (~92% VO2max) than for 1 minute intervals (~82% VO2max). Blood lactates and RPE were similar across all conditions, both increasing as each exercise bout progressed. The greatest physiological load was experienced in the 4-min intervals. Physiological loading in interval training is greatest when work intervals are four minutes. The shorter the interval, the less demanding is the work, but the greater is the potential volume of a particular work quality\textsuperscript{36}.

S. Berthoin, and Et.al\textsuperscript{37} assessed the impact of once-per-week training sessions on performance and fitness. Male (N = 57) and female (N = 64) students (age 14-17 yr) trained once a week on an intense or a moderate program of stimulation. Some Ss (N = 20) served as a no-training control group. Measurements were maximal aerobic speed (MAS) and running time to exhaustion at 100% MAS. The intense and moderate training programs differed by the ratio between continuous exercise (85% of MAS for 20-25


\textsuperscript{37} S. Berthoin, and Et.al. “Effect of a 12-week training programme on maximal aerobic speed (MAS) and running time to exhaustion at 100% of MAS for students aged 14 to 17 years”, \textit{Journal of Sports Medicine and Physical Fitness, 35}, (1995), 251-256.
min) and intermittent exercises (between 90% for 3-min intervals and 120% for 10-s intervals of MAS). The intense program did more interval work and the moderate program recovers continuous work. Only in the intense group were significant changes noted. Males improved 5.7% and females 5.4% in MAS. There were no significant changes in time to exhaustion. If once per week training is to be undertaken by adolescents, the greatest gains will be derived from high-intensity interval work.

Interval training and continuous running were compared for effects on physiological adaptations. Untrained men and women were randomly assigned to four groups: 1) running continuously at 75% HRmax for four miles; 2) running continuously at 75% HRmax for two miles; 3) eventually running eight one minute intervals at 90% HR max with three minute recovery intervals; and 4) no exercise control. Males (N = 24) and females (N = 35) completed. Training sessions were conducted three times per week for 12 weeks. Only the interval training group improved significantly more than the control group in VO2max. The response to training was similar between genders, although values differed between them. There were no differences in percentage of body fat changes, triglycerides, cholesterol, and
high density lipoproteins. Interval training benefits aerobic capacity more than continuous training\textsuperscript{38}.

Elite junior male soccer players were divided into an experimental group (N = 9) that experienced additional interval training as a stimulus for improving aerobic function for eight weeks, and a control group that trained normally. The interval training consisted of running 4 x 4-min at 90-95\% HR max with a 3-min group between-repetition recovery and jog. The interval group was the only group that improved aerobic function. VO2max improved 10.7\% and lactate threshold by 15.9\%. Running economy improved by 6.7\%; distance covered in a match increased by 20\%; and work level (measured by HR) increased by 3.5\%. The introduction of interval training in a season of endurance-based sport will increase the performance characteristics of athletes in competitions\textsuperscript{39}.


Recreationally trained Ss (M = 6; F = 2) performed SIT (6 bouts of 4-8 Wingate 30-s tests with 4-min recovery between tests) six times with 1-2 days of rest between sessions over two weeks. Performance was measured by a ride to exhaustion at ~80% VO2peak. Physiological measures were taken. VO2peak was unchanged over the training period. Maximum anaerobic work increased by 14% and cycle time to exhaustion increased ~101%. Lactate measures were unchanged as a result of the training. Judiciously applied sprint interval training and recovery resulted in improved intense aerobic work and to a lesser extent, anaerobic work\textsuperscript{40}.

Active men and women were assigned to three training or a control group: continuous training (N = 10; 70% VO2max for 30-50 minutes), interval training (N = 10; 85-100% VO2max 16-35 minutes), speed training (N = 10; 100% maximal speed in 20-50 m intervals for 300-400 m total distance per session), and control (N = 8). Training was for three days per week and lasted for eight weeks. Only speed training increased MAOD. It remained

\textsuperscript{40} S.C Hughes and et al. “Six bouts of sprint interval training (SIT) improve intense aerobic cycling performance and peak anaerobic power”, Medicine and Science in Sports and Exercise, 35(5) (2003), Supplement Abstract 1875.
unchanged in the other two forms of training. Moderate interval intensity training and continuous training mainly change aerobic power in exercise. Only supra maximal sprint training stimulates improvement in MAOD\textsuperscript{41}.

Effects of resistance training and short-duration interval training on rowing ergometer performance of collegiate women rowers (N = 24) during the transition phase of training. That phase typically consists of low intensity and volume endurance exercise combined with strength training. Ss were subjected to heavy resistance training or high intensity ergometer interval training two days per week. Across time, both groups improved 500-m time, 1 RM bench press, and body mass. There was no change in 2000-m time, blood lactate, VO2max, Profile of Mood States, 1 RM squat, or injury frequency. The added training changed few variables, the primary performance factor being sprint or anaerobic work. Aerobic performance factors were not changed. So the added work did not interfere with the

maintenance of that capacity. Sprint work or heavy resistance training improves short-duration performances but does not affect longer-duration performances in the transition phase of training\textsuperscript{42}.

Trained endurance athletes (N = 17) participated in a 5-day training camp where aerobic training was increased from 1 hour to 2-3 hours per day. Daily questionnaires were used to collect athletes' perceptions of exertion and recovery over the previous 24 hours. At the start and end of the camp, a 5 km running test at a set submaximal heart rate was performed. Higher parasympathetic tone was exhibited at the end of the camp. Average speed in the running test increased. Ratings of perceived exertion and physical exertion perceptions increased and compromised recovery feelings suggested overreaching was experienced after such a short period. Heart rate variability decreased. A 5-d training camp that increased aerobic training demands reduced the quality of athletes' exercise perceptions while improving heart rate variability and performance time.

While physiology and performance improved, psychological indicators declined\textsuperscript{43}.

Male college middle and long distance runners (N = 12) completed two different workouts separated by seven days. The long-interval workout consisted of 4 x 800 m run in 140 s with a recovery period of 120 s. The short-interval workout consisted of 8 x 400 m run in 70 s with a recovery period of 51 seconds. Thus, the total workouts were 15:20 with 6:00 of recovery and 9:20 of work for a total distance of 3200 m. Post-workout lactates were significantly higher in the long-interval when compared to the short-interval training. Short intervals with short recovery times keep lactate accumulation down while longer work and rest periods elevated it. Work and rest intervals will determine the amount of work that can be performed at of particular quality level at training. Short work and rest intervals are conducive to a greater volume of specific work being performed\textsuperscript{44}.


Means (M = 11; F = 16) were randomly assigned to a continuous (30 min/d; 4 d/wk) or interval (2 x 15-min/d; 4 d/wk) exercise groups. Training lasted 12 weeks and then the groups changed to the other's protocol for an additional 12 weeks. At week 24, VO2max improved more in the continuous-interval (CI) group (7.4%) than in the interval-continuous (IC) group (3.6%). Maximum time to exhaustion improved 15% in the CI group but only 5.3% in the IC group. Exercise economy improved at two different speeds in the CI group but did not change in the IC group. Changing from continuous to interval training produces more and better benefits than changing from interval to continuous training45.

Untrained young adults (N = 42) were randomly assigned to continuous or interval training groups. A separate control group of individuals not involved in training was also formed. Both groups trained three times per week for 10 weeks. The continuous constant-intensity training group started at 70% of VO2max for 30 minutes, built to 75% for 35 minutes by the end of the fifth

week, and by the end of the eighth week was at 80% for 40 minutes. The interval group performed a similar work volume but intensity varied between 120-150% VO2max and 30-40% during recovery intervals. Both experimental groups improved in VO2max, anaerobic treadmill time, and sprint time. The interval group improved significantly more than the continuous group in anaerobic treadmill time and sprint time. Isokinetic leg actions improved only in the interval group. Both interval and continuous training improved aerobic work. Interval training produced greater anaerobic benefits than continuous work46.

Male Ss (N = 12) participated in three trials of treadmill running under the following conditions: 15 s of work, 15 s of recovery; 30 s of work, 15 s of recovery; and 60 s of work, 15 s of recovery. Work was performed at 100% VO2max and recovery was performed at 50% VO2max. The total distance covered in work was intended to be 2400 m. A fourth trial was performed continuously at 100% VO2max. All Ss completed the 15:15 and 30:15 trials. Only five completed the 60:15 trials. Percent VO2max was lowest in the 15:15 trials. Percent VO2max was

similar in the 60:15 and continuous running trials. VO2max for the 30:15 trials fell in between the values of the 15:15 and 60:15 trials. Similar relationships were recorded for perceived exertion values and heart rates. Blood lactate values following the exercises were lowest for the 15:15 condition and similar for the three other conditions. The 30:15 condition appeared to stimulate both aerobic (VO2max) and anaerobic (high lactate at finish) mechanisms. The 15:15 condition stimulated aerobic adaptation with much less anaerobic stimulation. More work could have been achieved under the 15:15 condition\textsuperscript{47}.

Unless appropriate paces and intensities of work are prescribed for individuals, some swimmers may under-work while others will overwork. The task is to prescribe optimal training activities which involve the correct mix of aerobic endurance, aerobic power, lactate tolerance, and sprint ability. Each of those forms requires different intensities, duration of repetitions, and rest intervals. This is one's maximum velocity and is a function of muscle fiber type, level of creatine phosphate in the muscles, activity of creatine kinase in muscles, maximum muscle power, 

and neuromuscular recruitment patterns. A swimmer has to develop the skill of reaching maximum velocity as soon as possible in a race, to maintain maximum velocity for as long as possible, and develop the ability to call upon sprint ability in the middle and at the end of longer (>30 sec) races. When muscles contract they produce lactic acid because of incomplete oxidation of carbohydrate used as fuel. After its formation, it immediately splits to form lactate and hydrogen ions (H+). The H+ ions alter the acidity of the blood, lowering its pH value depending upon their concentration. This reaction is why the terms lactic acid and lactate are often used interchangeably. Thus, the pH of blood is a measure of the amount of H+ in the body. When the H+ ions are allowed to accumulate, the pH in the muscles falls, that is, the environment in the muscles increases in acidity. A normal resting measure of pH is 7.0 whereas in very strenuous work that predominantly uses anaerobic energy sources the level can drop to a value of 6.3. As the acidity level changes (the pH level is lowered), the muscles become weaker, often tighter, and the contractile force is reduced. As blood and muscle acidity increase, so does the feeling of fatigue. At low intensities of exercise, for example. AN Threshold training the rate at which lactic acid is produced is balanced by the rate at which it can be removed from
muscle and blood. However, as a swimmer speeds up, for example, at aerobic capacity speeds and “faster”, the use of carbohydrate as fuel the production of lactate is greater than the ability of the lactate-removal mechanisms. Thus, after a certain intensity of work, that is, swimming at a particular speed for a minimum duration, lactate accumulates. Resting or normal activity levels do not tax the capacity to remove lactate. Exercise can increase the production of lactate from 3-5 times above the resting level without any appreciable change in a muscle’s pH. This is because the body has buffers which combine with the H+ ions and remove them from bodily fluids. The greater the amount of buffer capacity, the greater can be the intensity of work before H+ ions accumulate and lower the blood pH. The buffering capacity of muscle determines its ability to tolerate lactate before the pH is altered noticeably. Fast twitch muscle fibers have a greater buffer capacity than slow twitch fibers. Buffer capacity can be increased through training. It is very helpful to assess a swimmer’s ability to tolerate lactate accumulation because it will indicate the changes derived from training designed to increase the amount of anaerobic work that can be sustained. This is a person’s maximum ability to use oxygen. It is the upper limit or ceiling for aerobic endurance. Endurance athletes have a high
capacity but it does not differentiate between them. It is a requirement for achieving an elite status but is not related to performance among an elite homogeneous group. This is a measure of an athlete's ability to perform prolonged, continuous exercise and depends upon physiological, biomechanical, nutritional, and psychological factors. The best measure currently available is the lactate or anaerobic threshold. It determines the maximum speed a swimmer can sustain without experiencing progressive accumulation of lactate in the blood. However, there are no pool races that use this capacity. Thus, its contribution to race quality is questionable. Rather, it serves as the basis for a general conditioned state. Two reasons justify aerobic endurance training. It contributes to accelerated recovery from fatiguing work and it extends one's ability to tolerate the demands of lactate tolerance, aerobic power, and speed training. This form of training may be the easiest and most efficient way of improving a swimmer's stroking economy which in turn, means that a swimmer can swim at faster speeds before reaching the lactate threshold\textsuperscript{48}.

Male students (N = 40) were randomly assigned to one of four groups performing similar workload: 1) long slow distance (70% maximal heart rate; HRmax), 2) lactate threshold (85% HRmax), 3) 15 x 15 seconds interval running (15 seconds running at 90-95% HRmax followed by 15 seconds active resting), and 4) 4 x 4 minutes interval running (4 minutes running at 90-95% HRmax followed by 3 minutes active resting at 70% HRmax). All groups trained three days per week for eight weeks. The training protocols were matched for total oxygen expenditure. High intensity interval training of 15 x 15 seconds and 4 x 4 minutes, respectively, resulted in significantly larger increases in maximal oxygen uptake compared to long slow distance and lactate threshold training intensities. The percentage increases for the interval training groups were 6.1% and 8.1%, respectively. The stroke volume of the heart changed significantly for the two interval groups. Changes in VO2max corresponded with changes in stroke volume of the heart, indicating a close link between the two. No significant changes or differences among groups were observed in lactate threshold when expressed as a percentage of VO2max. Running economy improved in all training groups with no differences between groups. High aerobic intensity interval
endurance training is significantly more effective than the same total work of low intensity training in improving VO2max\textsuperscript{49}.

Nine healthy males performed seven weeks of intense interval cycle ergometry training. Training effects were observed in both glycolytic and oxidative enzyme activity. A relatively brief period of sprint training increased aerobic and anaerobic capacities in initially untrained individuals. When training is initiated in untrained individuals, all systems respond to the exercise stimulation. It is only at the higher levels of performance/fitness that discriminative training responses occur\textsuperscript{50}.

Velocity at VO2max (vVO2max) and maximum time at that velocity (Tmax) are used to design individual training programs. Previous works showed that significant performance improvements resulted from interval training a vVO2max and 60% Tmax. This study evaluated the effects of training for four


weeks with an exercise intensity between 60-75% of Tmax as the interval duration. Trained male middle-distance runners (N = 8) were measured for physiological factors, a 3000m running time-trial, and three treadmill tests to determine Tmax. Training was on a motorized treadmill. Ss were re-tested following training. Significant increases in average vVO2max, Tmax, and VO2max were recorded after training. The 3000m time-trial performances were significantly improved. As the pace of training approaches race velocities, running velocity and physiological adaptations improve\textsuperscript{51}.

The aim was to examine the effects of seven high-intensity aerobic interval training (HIIT) sessions over 2 wk on skeletal muscle fuel content, mitochondrial enzyme activities, fatty acid transport proteins, peak O(2) consumption (Vo(2 peak)), and whole body metabolic, hormonal, and cardiovascular responses to exercise. Eight women (22.1 +/- 0.2 yr old, 65.0 +/- 2.2 kg body wt, 2.36 +/- 0.24 l/min Vo(2 peak)) performed a Vo(2 peak) test

and a 60-min cycling trial at approximately 60% Vo(2 peak) before and after training. Each session consisted of ten 4-min bouts at approximately 90% Vo(2 peak) with 2 min of rest between intervals. Training increased Vo(2 peak) by 13%. After HIIT, plasma epinephrine and heart rate were lower during the final 30 min of the 60-min cycling trial at approximately 60% pretraining Vo(2 peak). Exercise whole body fat oxidation increased by 36% (from 15.0 +/- 2.4 to 20.4 +/- 2.5 g) after HIIT. Resting muscle glycogen and triacylglycerol contents were unaffected by HIIT, but net glycogen use was reduced during the posttraining 60-min cycling trial. HIIT significantly increased muscle mitochondrial beta-hydroxyacyl-CoA dehydrogenase (15.44 +/- 1.57 and 20.35 +/- 1.40 mmol.min(-1).kg wet mass(-1) before and after training, respectively) and citrate synthase (24.45 +/- 1.89 and 29.31 +/- 1.64 mmol.min(-1).kg wet mass(-1) before and after training, respectively) maximal activities by 32% and 20%, while cytoplasmic hormone-sensitive lipase protein content was not significantly increased. Total muscle plasma membrane fatty acid-binding protein content increased significantly (25%), whereas fatty acid translocase/CD36 content was unaffected after HIIT. In summary, seven sessions of HIIT over 2 wk induced marked
increases in whole body and skeletal muscle capacity for fatty acid oxidation during exercise in moderately active women. The laboratory recently showed that six sessions of sprint interval training (SIT) over 2 wks increased muscle oxidative potential and cycle endurance capacity (Burgomaster KA, Hughes SC, Heigenhauser GJF, Bradwell SN, and Gibala MJ. J Appl Physiol 98: 1895-1900, 2005). The study tested the hypothesis that short-term SIT would reduce skeletal muscle glycogenolysis and lactate accumulation during exercise and increase the capacity for pyruvate oxidation via pyruvate dehydrogenase (PDH). Eight men [peak oxygen uptake (VO2 peak)=3.8+/−0.2 l/min] performed six sessions of SIT (4-7x30-s "all-out" cycling with 4 min of recovery) over 2 wks. Before and after SIT, biopsies (vastus lateralis) were obtained at rest and after each stage of a two-stage cycling test that consisted of 10 min at approximately 60% followed by 10 min at approximately 90% of VO2 peak. Subjects also performed a 250-kJ time trial (TT) before and after SIT to assess changes in cycling performance. SIT increased muscle glycogen content by approximately 50% (main effect, P=0.04) and the maximal activity of citrate synthase (post

training: 7.8+/−0.4 vs. pre training: 7.0+/−0.4 mol.kg protein -1.h-1; P=0.04), but the maximal activity of 3-hydroxyacyl-CoA dehydrogenase was unchanged (post training: 5.1+/−0.7 vs. pre training: 4.9+/−0.6 mol.kg protein -1.h-1; P=0.76). The active form of PDH was higher after training (main effect, P=0.04), and net muscle glycogenolysis (post training: 100+/−16 vs. pre training: 139+/−11 mmol/kg dry wt; P=0.03) and lactate accumulation (post training: 55+/−2 vs. pre training: 63+/−1 mmol/kg dry wt; P=0.03) during exercise were reduced. TT performance improved by 9.6% after training (post training: 15.5+/−0.5 vs. pre training: 17.2+/−1.0 min; P=0.006), and a control group (n=8, VO2 peak=3.9+/−0.2 l/min) showed no change in performance when tested 2 wks apart without SIT (post training: 18.8+/−1.2 vs. pre training: 18.9+/−1.2 min; P=0.74). It concluded that short-term SIT improved cycling TT performance and resulted in a closer matching of glycogenolytic flux and pyruvate oxidation during sub maximal exercise.  

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The study showed that 2 wk of daily sprint interval training (SIT) increased citrate synthase (CS) maximal activity but did not change "anaerobic" work capacity, possibly because of chronic fatigue induced by daily training. The effect of fewer SIT sessions on muscle oxidative potential is unknown, and aside from changes in peak oxygen uptake (Vo(2 peak)), no study has examined the effect of SIT on "aerobic" exercise capacity. We tested the hypothesis that six sessions of SIT, performed over 2 wk with 1-2 days rest between sessions to promote recovery, would increase CS maximal activity and endurance capacity during cycling at approximately 80% Vo(2 peak). Eight recreationally active subjects [age = 22 +/- 1 yr; Vo(2 peak) = 45 +/- 3 ml.kg(-1).min(-1) (mean +/- SE)] were studied before and 3 days after SIT. Each training session consisted of four to seven "all-out" 30-s Wingate tests with 4 min of recovery. After SIT, CS maximal activity increased by 38% (5.5 +/- 1.0 vs. 4.0 +/- 0.7 mmol.kg protein (-1).h(-1)) and resting muscle glycogen content increased by 26% (614 +/- 39 vs. 489 +/- 57 mmol/kg dry wt) (both P < 0.05). Most strikingly, cycle endurance capacity increased by 100% after SIT (51 +/- 11 vs. 26 +/- 5 min; P < 0.05), despite no change in Vo(2 peak). The coefficient of variation for the cycle test was 12.0%, and a control group (n = 8) showed
no change in performance when tested approximately 2 wk apart without SIT. One could conclude that short sprint interval training (approximately 15 min of intense exercise over 2 wk) increased muscle oxidative potential and doubled endurance capacity during intense aerobic cycling in recreationally active individuals\textsuperscript{54}.

Brief, intense exercise training may induce metabolic and performance adaptations comparable to traditional endurance training. However, no study has directly compared these diverse training strategies in a standardized manner. We therefore examined changes in exercise capacity and molecular and cellular adaptations in skeletal muscle after low volume sprint-interval training (SIT) and high volume endurance training (ET). Sixteen active men (21 +/- 1 years,) were assigned to a SIT or ET group (n = 8 each) and performed six training sessions over 14 days. Each session consisted of either four to six repeats of 30 s 'all out' cycling at approximately 250\% with 4 min recovery (SIT) or 90-120 min continuous cycling at approximately 65\% (ET). Training time commitment over 2 weeks was approximately 2.5 h for SIT and approximately 10.5 h for ET, and total training volume was

approximately 90% lower for SIT versus ET (approximately 630 versus approximately 6500 kJ). Training decreased the time required to complete 50 and 750 kJ cycling time trials, with no difference between groups (main effects, \( P \leq 0.05 \)). Biopsy samples obtained before and after training revealed similar increases in muscle oxidative capacity, as reflected by the maximal activity of cytochrome oxidase (COX) and COX subunits II and IV protein content (main effects, \( P \leq 0.05 \)), but COX II and IV mRNAs were unchanged. Training-induced increases in muscle buffering capacity and glycogen content were also similar between groups (main effects, \( P \leq 0.05 \)). Given the large difference in training volume, these data demonstrate that SIT is a time-efficient strategy to induce rapid adaptations in skeletal muscle and exercise performance that are comparable to ET in young active men\(^{55}\).

Low-volume "sprint" interval training (SIT) stimulates rapid improvements in muscle oxidative capacity that are comparable to traditional endurance training (ET) but no study has examined metabolic adaptations during exercise after these diverse training strategies. We hypothesized that SIT and ET would induce similar

adaptations in markers of skeletal muscle carbohydrate (CHO) and lipid metabolism and metabolic control during exercise despite large differences in training volume and time commitment. Active but untrained subjects (23+/−1 y) performed a constant-load cycling challenge (1 h at 65% of VO2peak) before and after 6 wks of either SIT or ET (n=5 men and 5 women per group). SIT consisted of 4-6 repeats of a 30 s "all out" Wingate Test with 4.5 min recovery per d, 3 dwk-1. ET consisted of 40-60 min of continuous cycling at ~65% VO2peak per d, 5 dwk-1. Weekly time commitment (~1.5 vs ~4.5 h) and total training volume (~600 vs ~3000 kJwk-1) was substantially lower in SIT vs ET. Despite these differences, both protocols induced similar increases (P<0.05) in mitochondrial markers for skeletal muscle CHO (pyruvate dehydrogenase E1alpha protein content) and lipid oxidation (3-hydroxyacyl CoA dehydrogenase maximal activity) and protein content of peroxisome-proliferator-activated receptor-gamma coactivator-1alpha. Glycogen and phosphocreatine utilization during exercise was reduced after training, and calculated rates of whole-body CHO and lipid oxidation were seen decreased and increased respectively, with no differences between groups (all main effects, P<0.05). Given the markedly lower training volume in the SIT group, these data suggest that high-
intensity interval training is a time-efficient strategy to increase skeletal muscle oxidative capacity and induce specific metabolic adaptations during exercise that are comparable to traditional ET\textsuperscript{56}.

The purpose was to examine the effects of sprint interval training on muscle glycolytic and oxidative enzyme activity and exercise performance. Twelve healthy men (22 +/- 2 yrs of age) underwent intense interval training on a cycle ergometer for 7 wks. Training consisted of 30-s maximum sprint efforts (Wingate protocol) interspersed by 2-4 minutes of recovery, performed three times per week. The program began with four intervals with 4 min of recovery per session in week 1 and progressed to 10 intervals with 2.5 min of recovery per session by week 7. Peak power output and total work over repeated maximal 30-s efforts and maximal oxygen consumption (VO2 max) were measured before and after the training program. Needle biopsies were taken from vastus lateralis of nine subjects before and after the program and assayed for the maximal activity of hexokinase, total glycogen phosphorylase, phosphofructokinase, lactate dehydrogenase, citrate synthase, succinate dehydrogenase, malate

dehydrogenase, and 3-hydroxyacyl-CoA dehydrogenase. The training program resulted in significant increases in peak power output, total work over 30s, and VO2 max. Maximal enzyme activity of hexokinase, phosphofructokinase, citrate synthase, succinate dehydrogenase, and malate dehydrogenase was also significantly (P < 0.05) higher after training. It was concluded that relatively brief but intense sprint training can result in an increase in both glycolytic and oxidative enzyme activity, maximum short-term power output, and VO2 max\textsuperscript{57}.

The purpose of this study was to investigate the effects of short-term, high-intensity sprint training on the root mean squared (RMS) and median frequency (MF) derived from surface electromyography (EMG), as well as peak power, mean power, total work, and plasma lactate levels in trained cyclists when performed concurrently with endurance training. Seventeen trained cyclists were randomly assigned to a sprint training (S) group (n = 10, age 25 +/- 2.0 y) or a control (C) group (n = 7, age 25 +/- 0.5 y). Sprint training was performed bi-weekly for four weeks, comprising a total of 28 min over the training period. EMG measurements were taken before and after training during a

series of four 30-s sprints separated by four minutes of active recovery. Plasma lactate, peak power, mean power, and total work were measured during each sprint bout. Following sprint training a significant increase occurred in the RMS of the vastus lateralis with a decrease in MF of the same muscle. Values for the vastus medialis did not change. Pre training exercising plasma lactate values were higher (p < 0.05) in C compared to S, but did not change with training. Exercising plasma lactate values increased (p < 0.05) from pre to post training in S, but were not different from C post training. Total work output increased from pre to post in S (p = 0.06). Peak power, mean power, and V.O (2)max increased (p < 0.05) pre to post training in S and C, indicating C was not a true control. In conclusion, these data suggest that four weeks of high-intensity sprint training combined with endurance training in a trained cycling population increased motor unit activation, exercising plasma lactate levels, and total work output with a relatively low volume of sprint exercise compared to endurance training alone\textsuperscript{58}.

Reports of violence and injuries to staff and patients in acute psychiatric inpatient settings have led to the development and implementation of training courses in the Prevention and Management of Violence and Aggression (PMVA). The purpose of the study was to explore the relationship between PMVA training of acute psychiatric ward nursing staff and officially reported violent incident rates. A retrospective analysis was conducted of training records (312 course attendances) and violent incident rates (684 incidents) over two-and-a-half years on 14 acute admission psychiatric wards (5,384 admissions) at three inner-city hospitals in the United Kingdom as part of the Tompkins Acute Ward Study. A positive association was found between training and rates of violent incidents. There was weak evidence that increased rates of aggressive incidents prompted course attendance, no evidence that course attendance reduced violence, and some evidence that attendance of briefer update courses triggered small short-term rises in rates of physical aggression. Course attendance was associated with a rise in physical and verbal aggression while staff were away from the ward. The failure to find a drop in incident rates after training, coupled with the small increases in incidents detected, raises concerns about the training course's efficacy as a preventive strategy. Alternatively,
the results are consistent with a threshold effect, indicating that once adequate numbers of staff have been trained, further training keeps incidents at a low rate\textsuperscript{59}.

This study expands the empirical and theoretical understanding of the distinction between those who perpetrate sexual assaults against children (child molesters) and those who perpetrate them against adults (rapists). Two questionnaires were completed by 88 incarcerated, male sexual offenders (45 child molesters and 43 rapists). The Spielberger state trait anxiety inventory and the Buss-Durkee hostility inventory. It was found that the rapists' level of aggression was significantly higher than that of the child molesters. No significant differences in anxiety levels were found between the two groups. The results are discussed in terms of their relevance to theory and clinical practice\textsuperscript{60}.


Aggression and body ideal hold important implications for the anxiety level associated with atopic dermatitis (AD). Most studies of aggression in AD have relied on self-evaluation measures or case descriptions. The study investigates the relationship between anxiety and management of aggression and body ideal, using the Karolinska Psychodynamic Profile (KAPP), a semi-structured interview quantifying clinical behavior. In KAPP body ideal, consists of 3 subscales: Bodily appearance (BA), bodily functioning (BF), and body image (BI). Thirty-one adult AD patients were compared on KAPP, trait anxiety (STAI), the anxiety index on the SCL-90, and skin condition (SCORAD). Aggression was significantly correlated with STAI \( r = 0.42, p < 0.05 \) and SCL-90 \( r = 0.48, p < 0.01 \). STAI, but not SCL-90, was correlated with BA \( r = 0.39, p < 0.05 \), BF \( r = 0.51, p < 0.01 \) and BI \( r = 0.36, p < 0.05 \). A post hoc analysis suggested that the SCL-90 depression index rather than anxiety is associated with BI. There was no relationship between SCORAD and KAPP or SCORAD and anxiety level. It is concluded that aggression and body ideal are important indicators for managing anxiety in AD, and that KAPP is a relevant inventory in the assessment of AD\(^{61}\).

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The authors examined whether attention deficit/hyperactivity disorder (ADHD) and callous-unemotional (CU) traits moderate the association between conduct problems (CPs) and impairment and aggression. Participants were 214 children who were rated by their elementary school classroom teachers. Results indicated that the association between CP and impairment and aggressive outcomes is almost always moderated by ADHD and/or CU. Moreover, in many instances, the association between CP and outcomes was moderated by both ADHD and CU such that the moderating effects of CU on CP were more pronounced at lower levels of ADHD. Results are discussed with respect to developmental taxonomies and trajectories of the disruptive behavior disorders.

The purpose of the study was to evaluate the validity of a modified version of the Taylor Aggression Paradigm (TAP) as a measure of direct physical aggression. Hypotheses were generated from recent theory pertinent to the categorization and measurement of aggressive behavior as well as widely supported effects of alcohol intoxication and gender on aggression.

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Participants were 328 (163 men and 165 women) healthy social drinkers between 21 and 35 years of age who completed self-report personality inventories designed to assess one's propensity toward direct physical aggression, verbal aggression, trait anger, and hostility. Following the consumption of either an alcohol or a placebo beverage, participants were tested on the TAP, in which mild electric shocks were received from, and administered to, a fictitious opponent during a competitive task. Direct physical aggression was operationalized as the shock intensities (i.e., first trial shock intensity, mean shock intensity, proportion of highest shock) administered to the fictitious opponent. Although all self-report measures were significantly associated with the three TAP indices, the associations involving physical aggression were strongest. In addition, self-report measures of physical aggression consistently predicted higher levels of aggression on the TAP indices in men, compared with women, and in intoxicated, relative to sober, participants. Taken as a whole, this pattern of findings provides further evidence for the validity of the TAP as a measure of direct physical aggression for men and women\textsuperscript{63}.

Anxious swimmers generally perform slower. The cognitive component of anxiety showed a stronger relationship to performance decline than the somatic component. However, the somatic-anxiety to performance relationship was found to be different between sprint and distance swimmers. Better-performing sprinters tended to control their somatic anxiety better than poorer performers. In distance events, better performers tended to attain higher levels of physiological arousal than poorer performers. It is important that swimmers approach competitions with confidence and a positive mind-set. Any negative talk is likely to indicate the swimmer has a strong likelihood of performing below expectations. For distance events, it is important to "get up" for a race, to mobilize sufficient energy to maintain a strong pace. However, sprinters must remain controlled with an optimum level of physiological arousal. The mental state of pre-race preparations is more important than the physical state that is attained. It is imperative that swimmers remain mentally controlled during the pre-race period.\[64\]

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Subjects (N = 45) were assessed for cognitive anxiety on the Sport Competition Anxiety Test (SCAT). Two months later they observed a person performing a new motor task which required high levels of cognitive processing (e.g., a variety of tasks in a specified order) to be performed well. Ss (N = 23) were then assigned to a mental practice group (the task was cognitively rehearsed) and a control group (N = 22) had no mental practice. Performance on the observed task was measured.

Errors and performance time interacted significantly with mental practice and no practice and SCAT scores. In the mental practice group, low SCAT scorers performed better than those scoring high. There was no effect of anxiety on control group performances. In cognitively-controlled physical tasks, when mental practice is involved, level of anxiety affects performances. When no mental practice is involved, anxiety does not affect performance.65

The purpose of the study was to identify temporal patterns, intensity, and direction of anxiety and self-confidence levels, and pre competitive performance expectations at three times (24, 2, and 1 hr) before competing. Volunteer high school and college

male and female athletes (N = 91) competing in soccer, swimming, and track and field served as Ss. The intensity of cognitive and somatic anxiety was measured with the CSAI-2. The direction of anxiety and self-confidence was measured with a facilitative/debilitative scale. Expectations about performance were assessed using a specially developed scale.

Athletes perceived cognitive anxiety, somatic anxiety, and self-confidence symptoms to be favorable for performance. Somatic anxiety was considered more facilitative than cognitive anxiety. Performance expectations were significantly related to self-confidence intensity and direction but not to somatic or cognitive anxiety.

Over time, cognitive anxiety did not change but somatic anxiety increased significantly from 24 hours to 1 hour. Self-confidence decreased slightly, but significantly over the same period. Performance expectations did not change with time. Once an athlete appraises anxiety symptoms as facilitative or debilitative, and assesses a level of expectation for performance, those evaluations remain consistent in the final 24 hours before
competing. The role of anxiety in performance is usually set more than 24 hours before a contest.66

Bowlers (M = 90; F = 53) represented recreational league participants (N = 95) and semi-professionals (N = 48). The Competitive State Anxiety Inventory-2 (CSAI-2) and the Sport Competition Anxiety Test (SCAT) were used to measure anxiety. Several significant, but trivial relationships were revealed. Cognitive anxiety had an inverted-U relationship with performance, accounting for 4.1% of relationship. The somatic direction subscale explained 3% of performance variance. Removing Ss with a repressive coping style produced a stronger and different anxiety-performance relationship. Cognitive intensity supported an inverted-U relationship and accounted for 12.6% of variance. Somatic intensity correlated negatively and accounted for 6.1% of performance variance.

These findings did not support multi-dimensional anxiety theory and offered marginal support for inclusion of directional interpretation scales. In bowlers, anxiety is a trivial factor that has little to do with performance.\textsuperscript{67}

Viewing aggression in its healthy form, in contrast to its extreme and inappropriate versions, and sport as a health-promoting exercise in psychological development and maturation may allow participants and spectators alike to retain an interest in aggression and sport and derive further enjoyment from them. In addition, it will benefit all involved with sport to have a broader understanding of human aggression. Physicians, mental health professionals, and other health care providers can be influential in this process, and should be willing to get involved and speak out when issues and problems arise\textsuperscript{68}.

The purpose of the study was to examine the relationship of goal orientations with aggression in male adolescent handball players across three institutional sport contexts, Physical Education, Interscholastic, and League (clubs). 30 handball players


games were videotaped (10 per context) and observed on monitor by means of a grid allowing the distinction between Instrumental (nonemotional and task-oriented) and Hostile (an emotional response which is an end in itself; aggression. 240 players also completed the "Questionnaire de Perception due Success en Sport." A main effect of context emerged from 2 separate one-way multivariate analyses of variance for goal orientations and aggression. Univariate F tests and Newman-Keuls post hoc analyses indicated that Ego-goal orientation and Instrumental aggression were significantly higher in the League context than in the other two. Statistically significant positive correlations between measures of Ego-goal orientation and aggression were observed. Discriminate function analysis indicated that strongly Ego-goal classified players displayed more Instrumental aggression than lower Ego-goal classified players.

The study assessed effect of one year of traditional judo training on aggressiveness among young boys. 27 primary school pupils and 28 judo students were asked to complete the Buss-Perry Aggression Questionnaire at two times 1 year apart. Analysis showed that judoka were more aggressive (had higher

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scores on Total Aggression, Verbal Aggression, and Anger) than the control group after one year of training, even if variations in aggressiveness were not significant. So, results do not support the view that judo training leads to less aggressiveness in a sample of children this young.\footnote{70}

The study examined changes in cognitive anxiety, somatic anxiety, and self-confidence as measured by the Competitive State Anxiety Inventory-2 in a sample of 50 female high school gymnasts prior to their performances at a practice session, dual meet, and district championship meet. The purpose of the study was to examine the relationship between state anxiety and (1) performance setting, (2) experience, and (3) difficulty of the movement task. Analysis showed that at the dual meet athlete's experienced significantly greater cognitive and somatic anxiety and lower self-confidence than at the practice or district championship. State anxiety did not vary significantly with the athletes' over-all experience or the difficulty of the routines they performed.

The unexpected finding that the dual meet was the most anxiety-provoking was attributed to the greater uncertainty of outcome in a competition and the fact that the dual meet occurred early in the season\textsuperscript{71}.