REVIEW OF RELATED LITERATURE
CHAPTER II

REVIEW OF RELATED LITERATURE

A study of relevant literature is an essential step to get a clear picture of what has been done with regard to the problem that is considered for the study. Such a review brings out a deep insight and clear perspective of the overall field. This chapter highlights the supporting evidences for the present study which is already done by different researchers from various countries. Supporting literature was collected from the various libraries and journals. Articles from newspapers, research papers from the journals, books, and other medical references have been used for collecting reviews.

Ivan Bautmans et al. (2005) conducted a study on Biochemical Changes in Response to Intensive Resistance Exercise Training in the Elderly. It is assumed that low-grade inflammation, characterized by increased circulating IL-6 and TNF-α, is related to the development of sarcopenia. Physical exercise, especially high intensity resistance training, has been shown to be effective in restoring the strength deficit in the elderly. Intensive exercise is accompanied by significant release of IL-6 and TNF-α into the blood circulation, but does not result in muscle wasting. Exercise-induced changes in heat-shock protein (Hsp), responsible for cellular protection during stressful situations, might interfere with the acute phase reaction and muscle adaptation. To investigate if intensive strength training in elderly persons induces changes in Hsp70 expression, and if these changes are related to changes in the acute phase reaction or muscle adaptation 31 elderly persons (aged 68.4 ± 5.4 years) performed 6 weeks intensive strength training. At baseline and after 6 weeks, muscle strength, functional performance (physical activity profile, 6-min walk, 30-second chair stand, grip strength, chair sit & reach and back scratch), linear isokinetic leg extension, circulating IL-6, TNF-α, IL-10, and TGF-β, and Hsp70 in monocytes (M) and lymphocytes (L) immediately after sampling (IAS), after incubation at 37 and 42°C were determined. In 12 participants, cytokines were determined in untrained and trained conditions before and after a single training session.

After 6 weeks training, muscle strength and functional performance improved significantly, together with decreased Hsp70 IAS and Hsp70 37°C and increased Hsp70 42°C (all \( p < 0.05 \)). Strength gains correlated positively with baseline Hsp70 37°C and training-induced changes of Hsp70 42°C in M and L. In an untrained condition, training induced an increase of IL-6 (\( p < 0.05 \)) and a tendency of IL-10 to decrease (\( p = 0.06 \)). In a trained condition the decrease of IL-10 disappeared. Baseline physical activity and 6-min walk distance correlated negatively with circulating IL-6 (\( p < 0.05 \)), except for a negative correlation between TGF-\( \beta \) and Hsp70 37°C L (\( p < 0.05 \)). No significant relationships were found between cytokines and Hsp70. After the training program, Hsp70 37°C was negatively related to circulating TNF-\( \alpha \), IL-10 and TGF-\( \beta \). Strength training in the elderly induces changes in Hsp70 expression, associated to strength gains and circulating cytokines.

Bosquet L, Leger L and Legros P (2001), conducted a study related to the blood lactate response to overtraining in male endurance athletes. Many physiological markers vary similarly during training and overtraining. This is the case for the blood lactate concentration ([La-]b), since a right shift of the lactate curve is to be expected in both conditions. We examined the possibility of separating the changes in training from those of overtraining by dividing [La-]b by the rating of perceived exertion ([La-]b/RPE) or by converting [La-]b into a percentage of the peak blood lactate concentration ([La-]b,peak). Ten experienced endurance athletes increased their usual amount of training by 100% within 4 weeks. An incremental test and a time trial were performed before (baseline) and after this period of overtraining, and after 2 weeks of recovery (REC). The [La-]b and RPE were measured during the recovery of each stage of the incremental test. We diagnosed overtraining in seven athletes, using both physiological and psychological criteria. We found a decrease in mean [La-]b,peak from baseline to REC [9 64 (SD 1 17), 8 16 (SD 1 31) and 7 69 (SD 1 84) mmol l-1, for the three tests, respectively, \( p < 0.05 \)] and a right shift of the lactate curve. Above 90% of maximal aerobic speed (MAS) there was a decrease of mean [La-]b/RPE from baseline to REC [at 100% of MAS of 105 41

(SD 17.48), 84.61 (SD 12.56) and 81.03 (SD 22.64) arbitrary units, in the three tests, respectively, P < 0.05), but no difference in RPE, its variability accounting for less than 25% of the variability of [La-]b/RPE (r = 0.49). Consequently, [La-]b/RPE provides little additional information compared to [La-]b alone. Expressing [La-]b as a %[La-]b,peak resulted in a suppression of the right shift of the lactate curve, suggesting it was primarily the consequence of a decreased production of lactate by the muscle. Since the right shift of the curve induced by optimal training is a result of improved lactate utilization, the main difference between the two conditions is the decrease of [La-]b, peak during overtraining. We propose retaining it as a marker of overtraining for long duration events, and repeating its measurement after a sufficient period of rest to make the distinction with overreaching.

Counts A J et al., (2007), conducted a study related to Monitoring changes in performance, physiology, biochemistry, and psychology during overreaching and recovery in triathletes. The present investigation compared responses in previously identified physiological, biochemical, and psychological markers of overreaching in triathletes. Sixteen experienced male triathletes (VO2max [mean +/- SD] = 55.7 +/- 4.9 mL kg (-1) min (-1), age = 31.3 +/- 11.7 yr) were divided into matched groups according to physical and performance characteristics, and were randomly assigned to either intensified training (IT) or normal training (NT) groups. Physiological, biochemical, and psychological measures were taken at baseline, following four weeks of overload training and following a two-week taper. The IT group completed 290% greater physical training load than the NT group during the overload period. The subjects completed a 3-km run time trial (3-km RTT) each week in order to assess the time course of change in endurance performance. 3-km RTT performance was significantly reduced (37 +/- 7.5 %, p < 0.05) following four weeks of overload training in the IT group confirming a state of overreaching. During the same period, 3-km RTT performance significantly improved in the NT group (3.0 +/- 1.1 %, p < 0.05). Following the two-week taper, 3-km RTT performance significantly improved in the IT group (7.0 +/- 5.6 %, p < 0.05).

Hemoglobin concentration significantly decreased and urea increased in both groups during the overload period \( (p < 0.05) \) During the taper hemoglobin normalized with a greater increase in the IT group compared to the NT group \( (p < 0.05) \) A significant increase in free testosterone to cortisol ratio was also observed in the IT group compared to the NT group during the taper \( (p < 0.05) \) No significant changes were observed for any other biochemical variables during the period of investigation The RESTQ-76 Sport questionnaire showed an impaired recovery-stress state with increased training load, which improved following the taper in the IT group \( (p < 0.05) \) These present results suggest that none of the physiological and biochemical variables measured in this study were effective for the early identification of overreaching in experienced triathletes However, the RESTQ-76 Sport questionnaire may provide a practical tool for recognizing overreaching in its early stages These findings have implications for monitoring training status in athletes in a practical training setting

Umeda et al, (2008), conducted a study on effects of intense exercise on the physiological and mental condition of female university judoists during a training camp To clarify the physical and mental fatigue caused by intense exercise and the relationship between the two types of fatigue, we examined changes in anthropometric and biochemical variables, neutrophil function, and the Profile of Mood States (POMS) questionnaire in 13 female university judoists attending a one-week training camp Blood glucose, total cholesterol, hemoglobin, leukocyte count, IgG, and phagocytic activity all decreased after the training camp compared with baseline \( (P \leq 0.046) \) Aspartate aminotransferase, lactate dehydrogenase, creatine kinase, and neutrophil oxidative burst activity increased after the training camp \( (P \leq 0.007) \) Of the POMS scores, that for Fatigue increased after the training camp \( (P = 0.041) \) and that for Vigour decreased \( (P = 0.042) \) The changes in several POMS scores correlated with the changes in blood biochemical variables In particular, the change in total mood disturbance was negatively associated with changes in myogenic enzymes \( (P \leq 0.032) \) Our results suggest that intense exercise during training camps for female judoists leads to the appearance and accumulation of mental and physical fatigue, which are related to each other

\[\text{Umeda et al., "Effects of Intense Exercise on the Physiological and Mental Condition of Female University Judosts during a Training Camp", Journal of Sports Science} \text{, 2008 Jul, 26(9) 897-904} \]
Yamamoto Y et al, (2008) conducted a study on effects of long-term training on neutrophil function in male university judoists. The main objective of this study is to clarify the effects of high-intensity and high-frequency long-term/chronic training on neutrophil function and serum levels of myogenic enzymes in male university judoists. Methods adopted in the particular study where the subjects were 24 male judoists who had stopped judo training for 6 months and then restarted their training. The following parameters were examined before and after a 2h unified exercise loading (UEL) at the beginning of the restarted quotidian training (pre-training) and at 2 months, 4 months and 6 months thereafter: myogenic enzymes, neutrophil and leucocyte counts, and neutrophil phagocytic activity (PA) and oxidative burst activity as a measure of reactive oxygen species (ROS) production capability. Myogenic enzymes that were measured after UEL at all four points significantly increased except for creatine kinase at the 2-month point (p<0.01 in each) and neutrophil counts significantly increased after UEL at the pre-training, 2-month and 4-month points (p<0.01 in each), but these changes became smaller from the 2-month point. PA significantly decreased after UEL at the pre-training and 2-month points (p<0.01 in each), but no change was seen at the 4-month and 6-month points. On the other hand, no change in ROS production per cell after UEL was seen at the pre-training point, but it significantly increased after UEL at the 2-month, 4-month and 6-month points (p<0.01 in each). Conclusion of the study says that the changing rate of the levels of UEL-mediated myogenic enzymes, neutrophil mobilisation and neutrophil function was seen to decrease at the 2-month, 4-month and 6-month assessments, compared with the pre-training point. These may comprise at least some of the long-term training effects.

Schmidt W and Prommer N (2008), conducted a study related to the effects of various training modalities on blood volume. It is controversially discussed whether soccer games should be played at moderate (2001-3000 m) and high altitudes (3001-5500 m) or should be restricted to near sea level and low altitude (501-2000 m) conditions. Athletes living at altitude are assumed to have a performance advantage compared with
lowlanders One advantage of altitude adaptation concerns the expansion of total hemoglobin mass (tHb-mass), which is strongly related to endurance performance at sea level. Cross-sectional studies show that elite athletes possess approximately 35% higher tHb-mass than the normal population, which is further elevated by 14% in athletes native to altitude of 2600 m. Although the impact of this huge tHb-mass expansion on performance is not yet investigated for altitude conditions, lowland athletes seek for possibilities to increase tHb-mass to similar levels. At sea level tHb-mass is only moderately influenced by training and depends more on genetic predisposition. Altitude training in contrast, using either the conventional altitude training or the live high-train low (>14 h/day in hypoxia) protocol for 3-4 weeks above 2500 m leads to mean increases in tHb-mass of 6.5%. This increase is, however, not sufficient to close the gap in tHb-mass to elite athletes native to altitude, which may be in advantage when tHb-mass has the same strong influence on aerobic performance at altitude as it has on sea level.

Silva A S et al. (2008) conducted a study related to the haematological parameters and anaerobic threshold in Brazilian soccer players throughout a training program, it was assessed the responses of hematological parameters and their relationship to the anaerobic threshold of Brazilian soccer players during a training program. Twelve athletes were evaluated at the beginning (week 0, T1), in the middle (week 6, T2), and at the end (week 12, T3) of the soccer training program. On the first day at 7:30 am, before collecting the blood sample at rest for the determination of the hematological parameters, the athletes were conducted to the anthropometric evaluation. On the second day at 8:30 am, the athletes had their anaerobic threshold measured. Analysis of variance with Newman-Keuls' post hoc was used for statistical comparisons between the parameters measured during the soccer training program. Correlations between the parameters analyzed were determined using the Pearson's correlation coefficient. Erythrocytes Concentration, Hemoglobin, and Hematocrit were significantly increased from T1 to T2. The specific soccer training program led to a rise in erythrocytes, hemoglobin, and hematocrit from T1 to T2. We assumed that these results occurred due to the plasma volume reduction and may be explained by the soccer training program characteristics.

Furthermore, we did not observe any correlation between the anaerobic threshold and the hematological parameters.

43 Fujitsuka S and Koike Y (2005) conducted study on effect of 12 weeks of strenuous physical training on hematological changes. It is well known that sports and physical exercise affect the hemoglobin (Hb) concentrations, however, the factors affecting the hematological changes after intense exercise are still not fully elucidated. In the present study, we examined the hematological and biochemical parameters of nine young male soldiers participating in a 12-week ranger training program. The platelet counts before the training showed a strong inverse correlation with the Hb concentrations after the training ($r = -0.829, p < 0.01$). Furthermore, the Hb concentrations of the subjects whose platelet counts were more than $25.0 \times 10^4$/μL decreased significantly after the training ($p < 0.05$). Our findings suggest that an association exists between high platelet counts even within the normal range before strenuous physical training and the risk of a subsequent decrease in the Hb concentrations.

44 Ostojic S M and Ahmetovic Z (2008) conducted a study on weekly training volume and hematological status in female top-level athletes of different sports. The objectives of the present study were to investigate the prevalence of iron depletion and anemia among female top-level athletes from different sports, to determine a relationship between serum ferritin levels and training status of female athletes. This study was conducted on 84 female professional athletes who were recruited during preparticipation physical examination. Upon entering the laboratory, 10 mL of venous blood was drawn from an antecubital vein into a lavender-top tube for a complete blood count (CBC), serum iron, and transferrin and ferritin levels. No significant differences between any of the hematological variables were found between groups of different sports. The lowest hemoglobin (Hb), mean corpuscular volume (MCV), serum iron, ferritin, and transferrin encountered in the study were Hb of 9.1 g/dL, MCV of 64.5 fL, serum iron of 15 microg/dL, ferritin of 5.4 microg/L, transferrin of 210 microg/dL in a 20-year old female.

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distance runner with functional impairment and iron deficiency anemia. No significant differences were found between female athletes from different sports regarding the prevalence of iron depletion, iron deficiency or iron deficiency anemia (IDA). Serum ferritin level poorly correlate with training duration ($r = 0.24$) and seems to be inadequate indicator of training tolerance. The study has shown a high prevalence of iron depletion and anemia among female athletes from different sports, with similar incidence in individuals independent of their weekly training volume.

45Musa D I et al, (2009) conducted a study related to the effect of a high-intensity interval training program on high-density lipoprotein cholesterol in young men and this study examined the impact of an 8-week program of high-intensity interval training on high-density lipoprotein cholesterol (HDL-C), total cholesterol (TC), and the atherogenic index (TC/HDL-C) in 36 untrained men ages 21-36 years. Participants were randomly assigned to an interval training group ($n = 20$) or a control group ($n = 16$). Participants in the experimental group performed 3.2 km of interval running (1:1 work:rest ratio) 3 times a week for 8 weeks at an intensity of 90% of maximal heart rate (approximately 423 kcal per session). Results indicated significant pre- to posttraining changes in HDL-C (1.1 vs 1.3 mmol/L, $p < 0.0001$) and TC/HDL-C (3.8 vs 3.1, $p < 0.0001$) but no significant changes in TC (3.9 vs 3.8 mmol/L, $p > 0.05$) with interval training. It was concluded that an 8-week program of high-intensity interval training is effective in eliciting favorable changes in HDL-C and TC/HDL-C but not TC in young adult men with normal TC levels. The findings support the recommendations of high-intensity interval training as an alternative mode of exercise to improve blood lipid profiles for individuals with acceptable physical fitness levels.
Wang J S and Chow S E (2004) conducted a study on effect of exercise training and detraining on oxidized low density lipoprotein potentiated platelet function in men. The main aim of study was to investigate how exercise training and detraining affect oxidized low-density lipoprotein (ox-ldl)-potentiated platelet function in men. Design cohort study Setting department of physical medicine and rehabilitation Participants ten sedentary men (mean age ± standard error of the mean, 21 6+/-0 2 y) who did not engage in any regular physical activity for at least 1 year before the study. Interventions subjects cycled on an ergometer at about 50% of maximal oxygen consumption for 30 minutes daily, 5 days a week, for 8 weeks, then detrained for 12 weeks. Main outcome measures during the experimental period, blood samples from the subjects were collected before and immediately after a progressive exercise test (ie, strenuous, acute exercise) every 4 weeks. The following measurements were taken when the subjects were at rest and immediately after exercise: plasma lipid profile, plasma ox-ldl level, and platelet aggregation and intracellular calcium concentration ([ca2+]i) elevation induced by adenosine disphosphate (adp) alone or simultaneous adp and ox-ldl addition. Results analytical results indicated that (1) plasma total cholesterol and ldl levels were reduced after exercise training from 151+/-7 mg/dl and 58+/-2 mg/dl to 133+/-6 mg/dl and 46+/-2 mg/dl (p< 05), respectively, whereas the plasma ox-ldl level remained unchanged, (2) platelet aggregation and [ca2+]i elevation promoted by 100 microg/ml of ox-ldl were significantly increased from 70%+/-5% and 91%+/-7% of resting level to 108%+/-4% and 125%+/-3% after strenuous, acute exercise (p< 05), (3) exercise training decreased resting and post exercise 100 microg/ml ox-ldl-potentiated platelet aggregation (ie, 31%+/-4% and 82%+/-4%, respectively, p< 05) and [ca2+]i elevation (ie, 35%+/-6% and 71%+/-4%, respectively, p< 05), (4) detraining reversed the training effects on lipid profile and platelet function, and (5) treating the platelet with l-arginine-inhibited ox-ldl-potentiated platelet activation during the experimental period. The results suggest that 8 weeks of exercise training decreased the plasma ldl level, but failed to influence production of plasma ox-ldl. Importantly, resting and exercise-induced ox-ldl-potentiated
platelet activation was decreased by exercise training. However, this was reversed by detraining to the pretraining level.

47Retallick C J et al, (2007) conducted a research on Plasma volume response to 30 sec cycle ergometry influence on lipid and lipoprotein. It has been suggested that exercise-induced changes in plasma volume (PV) confound the interpretation of biochemical data obtained during the recovery period from exercise. No studies have sought to assess the effect of short-duration, high-intensity exercise on PV change and plasma lipid and lipoprotein concentrations. The purpose of this study was to compare power profiles, changes in PV, and plasma lipid and lipoprotein concentrations immediately after and 24 h after exercise. Subjects undertook two 30-s, high-intensity cycle ergometer protocols after optimization of resistive loads calculated from total body mass (TBM) and fat-free mass (FFM). Power output indices were recorded and blood samples were analyzed before, immediately after, and 24 h after exercise. RESULTS Peak power outputs were significantly greater in FFM (1020 +/- 134 vs 953 +/- 114 W for FFM and TBM, respectively, P<0.05). No differences were found between TBM and FFM for mean power output, fatigue index, or work done. Significant decreases (P<0.05) in PV of 12.0 +/- 5.7% and 12.3 +/- 6.7% were recorded immediately after exercise for both TBM and FFM, respectively. At 24 h after exercise, a significant (P<0.05) increase in PV of 4.2 +/- 10.3% was recorded for TBM only. Significant increases (P<0.01) were recorded for serum triglyceride, cholesterol, HDL cholesterol, and LDL cholesterol immediately after exercise for both TBM and FFM. These increases disappeared when corrected for PV changes, with the exception of LDL cholesterol in TBM, which still displayed a significant increase compared with the preexercise values (2.50 +/- 0.74 mM (before) vs 2.72 +/- 0.84 mM (immediately after)). The data show that short-duration, high-intensity cycle ergometer exercise tests can induce significant plasma volume decreases in untrained subjects, which may affect the interpretation of blood borne biochemical parameters.

Mackinnon L T and Hubinger L M (1999) conducted a study related to the effects of exercise on lipoprotein (a) Lipoprotein (a) [Lp(a)] is a unique lipoprotein complex in the blood. At high levels (> 30 mg/dl), Lp(a) is considered an independent risk factor for cardiovascular diseases. Serum Lp(a) levels are largely genetically determined, remain relatively constant within a given individual, and do not appear to be altered by factors known to influence other lipoproteins (e.g., lipid-lowering drugs, dietary modification and change in body mass). Since regular exercise is associated with favourable changes in lipoproteins in the blood, recent attention has focused on whether serum Lp(a) levels are also influenced by physical activity. Population and cross-sectional studies consistently show a lack of association between serum Lp(a) levels and regular moderate physical activity. Moreover, exercise intervention studies extending from 12 weeks to 4 years indicate that serum Lp(a) levels do not change in response to moderate exercise training, despite improvements in fitness level and other lipoprotein levels in the blood. However, recent studies suggest the possibility that serum Lp(a) levels may increase in response to intense load-bearing exercise training, such as distance running or weight lifting, over several months to years. Cross-sectional studies have reported abnormally high serum Lp(a) levels in experienced distance runners and body builders who train for 2 to 3 hours each day. However, the possible confounding influence of racial or ethnic factors in these studies cannot be discounted. Recent intervention studies also suggest that 9 to 12 months of intense exercise training may elevate serum Lp(a) levels. However, these changes are generally modest (10 to 15%) and, in most individuals, serum Lp(a) levels remain within the recommended range. It is unclear whether increased serum Lp(a) levels after intense exercise training are of clinical relevance, and whether certain Lp(a) isoforms are more sensitive to the effects of exercise training. Since elevation of both low density lipoprotein cholesterol (LDL-C) and Lp(a) levels in the blood exerts a synergistic effect on cardiovascular disease risk, attention should focus on changing lifestyle factors to decrease LDL-C (e.g., dietary intervention) and increase high density lipoprotein cholesterol (e.g., exercise) levels in the blood.

Mackinnon L T and Hubinger L M. "The Effects of Exercise on Lipoprotein (a)" Sports Medicine 1999 Jul, 28(1) 11-24 Print
Branth S et al, (2009) conducted a study on Metabolic stress-like condition can be induced by prolonged strenuous exercise in athletes. Few studies have examined energy metabolism during prolonged, strenuous exercise. We wanted therefore to investigate energy metabolic consequences of a prolonged period of continuous strenuous work with very high energy expenditure. Twelve endurance-trained athletes (6 males and 6 females) were recruited. They performed a 7-h bike race on high work-load intensity. Physiological, biochemical, endocrinological, and anthropometric muscular compartment variables were monitored before, during, and after the race. The energy expenditure was high, being 5557 kcal. Work-load intensity (% of VO(2) peak) was higher in females (77.7%) than in men (69.9%). Muscular glycogen utilization was pronounced, especially in type I fibres (>90%). Additionally, muscular triglyceride lipolysis was considerably accelerated. Plasma glucose levels were increased concomitantly with an unchanged serum insulin concentration which might reflect an insulin resistance state in addition to proteolytic glyconeogenesis. Increased reactive oxygen species (malondialdehyde (MDA)) were additional signs of metabolic stress. MDA levels correlated with glycogen utilization rate. A relative deficiency of energy substrate on a cellular level was indicated by increased intracellular water of the leg muscle concomitantly with increased extracellular levels of the osmoregulatory amino acid taurine. A kindred nature of a presumed insulin-resistant state with less intracellular availability of glucose for erythrocytes was also indicated by the findings of decreased MCV together with increased MCHC (haemoconcentration) after the race. This strenuous energy-demanding work created a metabolic stress-like condition including signs of insulin resistance and deteriorated intracellular glucose availability leading to compromised fuelling of ion pumps, culminating in a disturbed cellular osmoregulation indicated by taurine efflux and cellular swelling.
Tolfrey K, Campbell I G and Batterham A M (1998) conducted a study on exercise training induced alterations in prepubertal children's lipid-lipoprotein profile. This study examined the effect of exercise training on prepubertal children's (ET, N = 28) lipid-lipoprotein profile, relative to a maturity matched control group (CON, N = 20).

**Methods**
Training for ET involved stationary cycling for 30 min, 3 times wk-1 for 12 wk, at 79.3 +/- 1.2% (mean +/- SD) peak heart rate (HR). Controls maintained their usual lifestyle pattern. Plasma concentrations of total triacylglycerol (TG), total cholesterol (TC), and high-density lipoprotein (HDL)-cholesterol (HDL-C) were determined pre- and postintervention. Low-density lipoprotein (LDL)-cholesterol (LDL-C) was subsequently estimated from these concentrations, and the ratios TC/HDL-C and LDL-C/HDL-C were also calculated. There were no pretest differences (P > 0.05) for any of these blood analytes between groups. The following, potentially, confounding variables were also measured: peak VO2, percent body fat (%BF), dietary composition, and habitual physical activity. These variables, with pretest HDL-C, were included as covariates in two-way split plot ANCOVA analyses. Dietary variables were not included as covariates as they were not related to any of the blood analyses. There were no differences over time or between groups for TG and TC (P > 0.05). LDL-C decreased in ET (-10.2%) but remained unchanged in CON (0.3%) over the intervention period (P < 0.05). HDL-C increased in ET (9.3%) but decreased in CON (-8.9%) (P < 0.01). A similar, but inverted, pattern of change (P < 0.01) was revealed for both ratios, TC/HDL-C (-11.6% vs 6.3%, ET and CON, respectively), and LDL-C/HDL-C (-17.2% vs 8.0%, ET and CON, respectively). The favorable alterations in the lipid-lipoprotein profile for ET were independent of alterations in peak VO2 (group x time interaction, P < 0.05), %BF (main effect time, P < 0.01), and habitual physical activity (group x time interaction, P < 0.01).

In conclusion, the favorable alterations in the lipoprotein profile seen in this study would suggest that it is possible to influence the prepubertal lipoprotein profile independent of...
alterations in confounding variables such as body composition, cardiorespiratory fitness, and habitual physical activity

Mujika I et al., (2004) conducted a study related to the physiological changes associated with the pre-event taper in athletes. Some of the physiological changes associated with the taper and their relationship with athletic performance are now known. Since the 1980s, a number of studies have examined various physiological responses associated with the cardiorespiratory, metabolic, hormonal, neuromuscular and immunological systems during the pre-event taper across a number of sports. Changes in the cardiorespiratory system may include an increase in maximal oxygen uptake, but this is not a necessary prerequisite for taper-induced gains in performance. Oxygen uptake at a given submaximal exercise intensity can decrease during the taper, but this response is more likely to occur in less-skilled athletes. Resting, maximal and submaximal heart rates do not change, unless athletes show clear signs of overreaching before the taper. Blood pressure, cardiac dimensions and ventilatory function are generally stable, but submaximal ventilation may decrease. Possible hematological changes include increased blood and red cell volume, hemoglobin, hematocrit, reticulocytes and haptoglobin, and decreased red cell distribution width. These changes in the taper suggest a positive balance between hemolysis and erythropoiesis, likely to contribute to performance gains. Metabolic changes during the taper include reduced daily energy expenditure, slightly reduced or stable respiratory exchange ratio, increased peak blood lactate concentration, and decreased or unchanged blood lactate at submaximal intensities. Blood ammonia concentrations show inconsistent trends, muscle glycogen concentration increases progressively and calcium retention mechanisms seem to be triggered during the taper. Reduced blood creatine kinase concentrations suggest recovery from training stress and muscle damage, but other biochemical markers of training stress and performance capacity are largely unaffected by the taper. Hormonal markers such as testosterone, cortisol, testosterone/cortisol ratio, 24-hour urinary cortisol/cortisone ratio, plasma and

Mujika I et al., “Physiological Changes Associated With the Pre-Event Taper in Athletes”, Journal of Sports Medicine 2004 34(13) 891-927 Print
urinary catecholamines, growth hormone and insulin-like growth factor-1 are sometimes affected and changes can correlate with changes in an athlete's performance capacity. From a neuromuscular perspective, the taper usually results in markedly increased muscular strength and power, often associated with performance gains at the muscular and whole body level. Oxidative enzyme activities can increase, along with positive changes in single muscle fibre size, metabolic properties and contractile properties. Limited research on the influence of the taper on athletes' immune status indicates that small changes in immune cells, immunoglobulins and cytokines are unlikely to compromise overall immunological protection. The pre-event taper may also be characterised by psychological changes in the athlete, including a reduction in total mood disturbance and somatic complaints, improved somatic relaxation and self-assessed physical conditioning scores, reduced perception of effort and improved quality of sleep. These changes are often associated with improved post-taper performances. Mathematical models indicate that the physiological changes associated with the taper are the result of a restoration of previously impaired physiological capacities (fatigue and adaptation model), and the capacity to tolerate training and respond effectively to training undertaken during the taper (variable dose-response model). Finally, it is important to note that some or all of the described physiological and psychological changes associated with the taper occur simultaneously, which underpins the integrative nature of relationships between these changes and performance enhancement.

Kargotich S and Goodman C (1998) conducted a research on the influence of exercise-induced plasma volume changes on the interpretation of biochemical parameters used for monitoring exercise, training and sport. A number of studies have demonstrated considerable plasma volume changes during and after exposure to different environmental and physiological conditions. These changes are thought to result from transient fluid shifts into (haemodilution) and out of (haemoconcentration) the intravascular space. If the levels of plasma constituents are to be routinely measured for
research purposes or used as indicators of training adaptation or the health of an athlete, then it is important to consider the dynamic nature of plasma volume. Controversy still exists over the relevance of plasma volume interactions with plasma constituent levels, and while some investigators have taken plasma volume shifts into account, others have chosen to ignore these changes. Bouts of acute exercise have been shown to produce a transient haemoconcentration immediately after long distance running, bicycle ergometry and both maximal and submaximal swimming exercise. While these changes are transient, lasting only a few hours, other studies have reported a longer term haemodilution following acute exercise. In addition, endurance training has been shown to cause long term expansion of the plasma volume. It would, therefore, seem important to consider the influence of plasma volume changes on plasma solutes routinely measured for research and as markers of training adaptation, prior to arriving at conclusions and recommendations based purely on their measured plasma level. To further confound this issue, plasma volume changes are known to be associated with heat acclimatisation, hydration state, physical training and postural changes, all of which may differ from one experiment or exercise bout to the next, and should thus be taken into account.

Wang J S et al., (1994) conducted a study related to the different effects of strenuous exercise and moderate exercise on platelet function in men. The platelets play an important role in the pathogenesis of cardiovascular diseases. It is also noticed that on one hand, regular exercise can reduce the risk of cardiovascular diseases, and on the other hand, vigorous exercise provokes sudden cardiac death. We therefore hypothesize that various intensities of exercise may affect platelet function differently. Strenuous and moderate exercise (about 50% to 55% of peak oxygen consumption, VO2peak) on a bicycle ergometer in 10 sedentary and 10 physically active healthy young men was executed on two separate occasions. Blood samples were collected before and immediately after exercise. A newly designed tapered parallel plate chamber was used to assess platelet adherence. Platelet aggregation induced by ADP was evaluated by the

percentage of reduction in single platelet count beta-Thromboglobulin (beta-TG) and platelet factor 4 (PF4) were measured by ELISA. In addition, a similar study on 5 patients with stable angina was also conducted. The results showed that (1) in the sedentary healthy group, platelet adhesiveness and aggregation were increased by strenuous exercise and depressed by moderate exercise, (2) in the active healthy group, platelet adhesiveness and aggregation were enhanced by severe exercise, whereas only aggregation was decreased by moderate exercise, (3) in the patients with stable angina, platelet adhesiveness and aggregation were enhanced by strenuous exercise and adhesiveness was suppressed by moderate exercise, (4) the degree of hemoconcentration induced by acute exercise tended to be related to the severity of exercise in all subjects, and (5) although severe exercise elevated beta-TG and PF4, there were no significant changes in beta-TG, PF4, and the ratio of beta-TG to PF4 in healthy subjects after exercise. It is concluded that platelet adhesiveness and aggregability may be sensitized by strenuous exercise in both healthy subjects and patients with stable angina. In contrast, platelet function can be suppressed significantly by moderate exercise in the healthy and tends to be depressed in patients with stable angina. The former may increase the risk of cardiac arrest and the latter may protect us from cardiovascular diseases. In addition, the effects of acute exercise tend to be more pronounced in the sedentary than in the active.

Davis R B et al., (1990) conducted a study related to the effects of exercise and exercise conditioning on blood platelet function. The effects of exercise and exercise conditioning on blood platelet function were investigated in six healthy individuals who had not engaged in regular exercise for at least 1 yr prior to the study. The subjects (three men and three women) had a mean age of 28 (range 23-32) and participated in a supervised program of treadmill exercise. Subjects exercised for 20 min, three times weekly, for 12 wk at 70-80% of estimated maximum heart rate. Samples for platelet counts, platelet aggregation, and plasma beta-thromboglobulin (beta-TG) were obtained prior to training and after 6 and 12 wk of training. All subjects responded with an increase in aerobic capacity during training. Resting mean systolic and diastolic blood pressures decreased after training (P less than 0.05). Platelet counts increased after

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exercise, and the increment in week 12 exceeded that in the 1st wk by 57%. Platelet aggregation studies in platelet rich plasma (PRP) showed an increase in slope after exercise (week 1, \( P < 0.05 \)) which decreased with training (week 1 vs week 12, \( P < 0.01 \)). Aggregation studies utilizing impedance aggregometry in diluted native whole blood showed an acceleration of both spontaneous aggregation (\( P < 0.01 \) weeks 6 and 12) and aggregation using epinephrine as an agonist (\( P < 0.05 \)) following exercise. Plasma beta-TG levels did not increase significantly after exercise, however, resting concentrations of beta-TG decreased with training (\( P < 0.03 \)).

\(^{55}\) EL-Sayed M S, Ali N and Ali Z (2005) conducted a research on aggregation and activation of blood platelets in exercise and training. The review presents an overview of the progress that has been made in recent years in understanding of the interaction between exercise and platelets in health and disease by researchers. Although platelets are important in normal hemostasis, recent evidence emphasises the pivotal role of abnormal platelet function in acute coronary artery diseases, myocardial infarction, unstable angina and stroke. In light of the positive health benefits of exercise, interest has been heightened on the association between exercise and platelet aggregation and function, not only in normal healthy subjects but also in patients. However, the studies of exercise effects on blood platelets are highly contentious because of the fact that the analytical methods employed to study platelets are bedevilled by numerous methodological problems. While exercise effects on platelet aggregation and function in healthy individuals have been extensively examined, the evidence reported has been conflicting. Somewhat less contradictory are the results generated from studies in patients with coronary heart disease, as the preponderance of evidence available would strongly suggest that platelet aggregation and function are increased with exercise. Several drugs are known to influence platelet aggregation and function, the most examined among these medications is aspirin (acetylsalicylic acid). However, aspirin appears to be ineffective to attenuate exercise-induced increases in platelet aggregation and activation. Few studies are available on the effect of training on blood platelets and the exact effects of exercise.

training on platelet activation and function is not as yet known. This lack of information makes further studies particularly important, in order to clarify whether there are favourable effects of exercise training on platelet aggregation and function in health and disease.

56. El-Sayed M S (2002) did a study related to exercise and training effects on platelets in health and disease. In recent years the involvement of platelets dysfunction in atherogenesis and in the clinical complications from atherosclerosis has become more recognised. Systemic platelet-related thrombogenic factors have been shown to be involved in the initiation and progression of atherogenesis and plaque growth. Over the last two decades, interest has been heightened regarding the changes in platelet aggregation and functions that are associated with exercise in normal subjects and also patients, particularly those suffering from coronary artery disease. Although exercise effects on platelet aggregation and function in healthy individuals have been examined, the results reported have been conflicting, most likely due to methodological problems in the measurements of platelet aggregation and activation during and after exercise. However for patients suffering from coronary heart disease, the balance of evidence available would strongly suggest that platelet aggregation and function are increased with exercise. Several drugs are known to affect platelets, the most studied among them is aspirin. The evidence available would suggest that aspirin is ineffective in attenuating enhanced platelet aggregation and activation induced by exercise. Although the effects of physical training have been briefly investigated, available meager evidence suggests that exercise on a regular basis is associated with favourable effects on platelets aggregation and activation in both men and women.

57. Thomas T R and Adeniran S B (1984) have conducted a study related to the effects of different running programs on VO2 maximum, percent fat and plasma lipids. This study attempted to determine the effects of interval and continuous running on factors associated with cardiovascular health. Fifty-nine untrained men and women, ages

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56. El-Sayed M S, "Exercise and Training Effects on Platelets in Health and Disease" Platelets 2002 Aug-Sep, 13(5-6), 261-6 Print
18-32 years, were randomly assigned to one of four groups (1) 4 mile running continuously at 75% of maximal heart rate (approximately 500 Cal/session) (2) 2 mile running continuously at 75% of maximal heart rate (approximately 250 Cal/session) (3) interval running one min at 90% maximal heart rate followed by three min of walking for eight sets (approximately 500 Cal/session) (4) control no exercise program The training was performed three times per week for 12 weeks Treadmill VO2 max and percent body fat by hydrostatic weighing were assessed pre- and post training Pre and post analyses were performed on plasma for triglycerides (TG), cholesterol (Chol), and high density lipoprotein cholesterol (HDL-C) Analysis of covariance indicated that only the interval group improved more than the control in VO2 max Percent fat decreased in all exercise groups, but no program was superior Changes in TG, Chol, or HDL-C were not different among groups Although men and women differed on the pretests in VO2 max, percent fat, and HDL-C, their response to the training was similar These results indicate that interval training may benefit aerobic capacity more than continuous running in young adults who have moderately high initial fitness levels The data also indicate that cardiovascular fitness parameters are not easily altered by short term exercise in young active men and women

Koutedakis Y (1995) conducted a study related to the seasonal variation in fitness in competitive athletes In many sports, training for successful competition has become virtually a year-round endeavor To assist in better preparation, a competitor's year may be divided into phases such as off-season and in-season, indicating reduced or increased competition commitments, respectively A number of studies have described the effects of seasons or periods of competition, training, detraining and reduced training on aspects of physical fitness Depending on performance level, the type of sport and the fitness parameter in question, the swings in fitness variables reported may be as high as 18% from one season to another In elite competitors, anaerobic parameters, heart frequencies, subcutaneous fat, flexibility and hemoglobin levels remain relatively unchanged throughout the year Aerobic metabolism and muscular strength may

demonstrate noticeable (mostly unfavourable) changes, and plasma hormonal levels normally follow changes in training intensities. Aspects related to long term fatigue and genetics, and to appropriate training are just a few explanations for these observations. It is still not known whether greater fitness gains attainable with longer off-season training programmes can be successfully maintained over the duration of the competition season. However, the consensus would seem to be that specialised training (based on technique and competition tactics only) is inadequate for fitness maintenance and/or improvements. This is perhaps supported by the general trends found in the literature regarding muscular strength. While supervised off-season conditioning programmes may result in significant improvements for both recreational and competitive athletes, no such changes are normally observed after competition seasons. These findings may reflect, amongst other factors, a lack of optimal training intensity to bring about strength increases during in-season periods. In novices and in athletes at low competitive levels, training seasons may lead to considerable functional improvements of the cardiorespiratory system, coupled with occasional increases in muscular strength and decreases in body fat. Relatively low fitness levels at the beginning of training have been put forward as an explanation for these improvements. Seasons of training and competition result in no significant changes in flexibility measurements. Similar changes to those found in novices and in athletes at low competitive levels may also be seen in children and adolescents engaged in sport, although their fitness improvements are consistent with normal patterns of growth and development. No differences have been identified between male and female athletes participating at different competition levels.

Tanaka H, Bassett and Howley, conducted a study related to the effects of swim training on body weight, carbohydrate metabolism, lipid and lipoprotein profile. The beneficial effects of regular exercise are primarily based on data using land-based exercise. Currently, no data exist that demonstrate the efficacy of swimming exercise for the treatment of obesity and cardiovascular risk factors, despite the fact that swimming is a widely recommended exercise mode. Eighteen previously sedentary obese individuals were divided into a swim-training group and a non-exercising control group. The training
group swam at 60% of maximal heart rate reserve for 45 min per day for 3 days per week for 10 weeks, whereas the control group remained sedentary. The swim-training programme produced significant cardiovascular training effects, as evidenced by reductions (P < 0.05) in resting and submaximal heart rate values in the training group. Significant reductions (P < 0.05) were also observed in the rating of perceived exertion and blood lactate concentrations during fixed submaximal exercise on an arm cycle ergometer. Caloric and macronutrient intake estimated from the dietary records stayed constant before and after training. Body mass, body fat percentage (36 +/- 2% vs 35 +/- 2%) and body mass index, as well as regional adiposity, showed no statistically significant changes. Neither the training nor the control groups experienced significant changes in fasting serum glucose and insulin concentrations and glucose-insulin ratio during the study. Total, high-density lipoprotein (HDL-) and low-density lipoprotein (LDL)-cholesterol did not change significantly in either group. It was concluded that swim training of the duration, frequency, and intensity used in the present study failed to elicit favourable modifications in these traditional cardiovascular risk factors.

Wilmore J H et al. (2001) conducted a study related to the changes in blood lipids consequent to aerobic exercise training related to changes in body fatness and aerobic fitness. The contribution of changes in body fatness and aerobic fitness to changes in blood lipids after aerobic exercise training was investigated. The sample included 295 men (77 black, 218 white) and 355 women (131 black, 224 white), aged 17 to 65 years, from the heritage Family Study. Participants underwent measurements at baseline and after 20 weeks of supervised exercise training on a cycle ergometer. Body fat mass (FM, in kilograms) was determined by underwater weighing, and aerobic fitness (maximal oxygen uptake, VO2max, in milliliters per minute) was assessed by cycle ergometry. Blood lipid measurements included fasting plasma levels of high-density lipoprotein cholesterol (HDL-C), HDL(2)-C, HDL(3)-C, low-density lipoprotein cholesterol (LDL-C), total cholesterol (CHOL), CHOL/HDL, and triglycerides (TG). A composite lipid change index (LCI) was derived by subjecting the Delta scores for the individual blood lipids to principal components analysis. The exercise training was

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Wilmore J H et al., "Changes in Blood Lipids Consequent to Aerobic Exercise Training Related to Changes in Body Fatness and Aerobic Fitness" Metabolism 2001 Jul, 50(7) 841-8 Print
accompanied by a mean increase of 17.5% in VO\(_{2\text{max}}\) and a mean decrease of 3.3% in FM. Partial correlations, controlled for age, between absolute changes in VO\(_{2\text{max}}\) and changes in the blood lipids were consistently low and nonsignificant. On the other hand, absolute changes in FM were significantly (P < 0.05) associated with changes in HDL-C (r = -0.23), HDL(2)-C (r = -0.17), and CHOL/HDL (r = -0.24) and the LCI (r = -0.27) in men and with changes in LDL-C (r = -0.22), CHOL (r = -0.19), and CHOL/HDL (r = 0.15) and the LCI (r = -0.19) in women. Forward stepwise regression confirmed that the change in FM was a better predictor of changes in blood lipids than the change in VO\(_{2\text{max}}\), entering as a predictor in 4 of 8 regressions in both men and women. Change in VO\(_{2\text{max}}\) did not enter as a significant predictor in any regression. Further, there were no differences in LCI between the upper and lower quartiles of VO\(_{2\text{max}}\) change. On the other hand, there were significant differences between the low and high quartiles of FM change. No race effects were observed in any of the relationships, except that race was a significant predictor of changes in TG in both men and women. In conclusion, changes in blood lipids associated with aerobic exercise training do not appear to be related to changes in aerobic fitness per se, rather, they are weakly to moderately associated with changes in body fatness.

61Stasiulis A et al., (2010) conducted a study related to the Aerobic Exercise-Induced Changes in Body Composition and Blood Lipids in Young Women. The objective of the study was to assess changes in body composition, blood lipid and lipoprotein concentrations in 18-24-year-old women during the period of two-month aerobic cycling training. Material and Methods Young, healthy, nonsmoking women (n=19) volunteered to participate in this study. They were divided into two groups: experimental (E, n=10) and control (C, n=9). The subjects of group E exercised 3 times a week with intensity of the first ventilatory threshold and duration of 60 min. The group C did not exercise regularly over a two-month period of the experiment. The subjects of group E were tested before and after 2, 4, 6 and 8 weeks of the experiment. The participants of group C were tested twice with an eight-week interval. Results Body weight, body mass index, body fat mass, and triglyceride (TAG) concentration

61Stasiulis A et al., "Aerobic Exercise-Induced Changes in Body Composition and Blood Lipids in Young Women" Medicina (Kaunas) 2010, 46(2) 129-34 Print
decreased and high-density lipoprotein cholesterol (HDL-ch) concentration increased after the 8-week training program in the experimental group (P<0.05). Blood total cholesterol (Tch) and low-density lipoprotein cholesterol (LDL-ch) concentrations did not change significantly. Body weight and body mass index started to decrease after 2 weeks of the experiment, but significant changes were observed only after 6 and 8 weeks. Body fat mass was significantly decreased after 2 and 8 weeks of aerobic training. A significant increase in HDL-ch concentration was observed after 4, 6, and 8 weeks. A significant decrease in TAG concentration was observed after 2-week training. No significant changes in all the parameters except TAG (it was slightly increased) were seen in the control group. The two-month aerobic cycling training (within VT1, 60-min duration, three times a week) may induce significant changes in the parameters of body composition—body weight, body mass index, body fat mass, and blood lipids—in young women. The following significant changes were observed: TAG level decreased after 2 weeks, body mass and body mass index decreased after 6 weeks, body fat mass decreased, and HDL-ch level increased after 8 weeks. Peak oxygen uptake increased after 4 weeks.

62 Siegel A J, Silverman L M and Lopez R E (1980) conducted a study related to the Creatine kinase elevations in marathon runners relationship to training and competition. Elevation of creatine kinase (CK) in serum after exertion is a reliable marker of skeletal muscle injury. Limited data exist on CK levels in conditioned athletes after endurance training and competition. Serum CK was measured by a kinetic UV method (normal < 100 U/L) in 15 long distance runners before (pre-race), 24 hours after (post-race) and four weeks following (post-race) the 1979 Boston Marathon. CK levels were elevated throughout the study. Mean values for all runners and for those finishing before and after three hours and 30 minutes are as follows: Post-race CK was significantly elevated among the ten faster as compared to the five slower runners (p = 0.025). Elevations of creatine kinase drawn 24 hours post-marathon are inversely related to finishing times among the runners tested.
Brancaccio P, Maffulli N and Limongelli F M (2007) conducted a study related to the Creatine kinase monitoring in sports medicine. Total creatine kinase (CK) levels depend on age, gender, race, muscle mass, physical activity and climatic condition. High levels of serum CK in apparently healthy subjects may be correlated with physical training status, as they depend on sarcomere damage. Strenuous exercise that damages skeletal muscle cells results in increased total serum CK. The highest post-exercise serum enzyme activities are found after prolonged exercise such as ultra distance marathon running or weight-bearing exercises and downhill running, which include eccentric muscular contractions. Total serum CK activity is markedly elevated for 24 h after the exercise bout and, when patients rest, it gradually returns to basal levels. Persistently increased serum CK levels are occasionally encountered in healthy individuals and are also markedly increased in the pre-clinical stages of muscle diseases. Areas that are controversial. Some authors, studying subjects with high levels of CK at rest, observed that, years later, subjects developed muscle weakness and suggested that early myopathy may be asymptomatic. Others demonstrated that, in most of these patients, hyperCKemia probably does not imply disease. In many instances, the diagnosis is not formulated following routine examination with the patients at rest, as symptoms become manifest only after exercise. Some authors think that strength training seems to be safe for patients with myopathy, even though the evidence for routine exercise prescription is still insufficient. Others believe that, in these conditions, intense prolonged exercise may produce negative effects, as it does not induce the physiological muscle adaptations to physical training given the continuous loss of muscle proteins. Growing points. High CK serum levels in athletes following absolute rest and without any further predisposing factors should prompt a full diagnostic workup with special regards to signs of muscle weakness or other simple signs that, in both athletes and sedentary subjects, are not always promptly evident. These signs may indicate subclinical muscle disease, which training loads may evidence through the onset of profound fatigue. It is probably safe to counsel athletes with suspected myopathy to continue to undertake physical activity at a lower intensity, so as to prevent muscle damage from high intensity exercise and allow

ample recovery to favour adequate recovery. Areas timely for developing research. CK values show great variability among individuals. Some athletes are low responders to physical training, with chronically low CK serum levels. Some athletes are high responders, with higher values of enzyme. The relationship among level of training, muscle size, fibre type, and CK release after exercise should be investigated further. In addition, more details about hyperCKemia could come from the evaluation of the kinetics of CK after stress in healthy athletes with high levels of CK due to exercise, comparing the results with the ones obtained from athletes with persistent hyperCKemia at rest. Finally, it would be important to quantify the type of exercise more suited to athletes with myopathy and the intensity of exercise not dangerous for the progression of the pathology.

64 Tomasik M (1979) conducted a study on physical exercise effect on erythrocyte metabolism. A group of 27 canoeists from the national team and 35 subjects beginning training in a sports discipline were subjected to investigations for determination of glucose utilization by erythrocytes, and the level of lactic acid in these cells and in serum. Furthermore, erythrocyte count and hematocrit value were determined in them. Both groups performed submaximal and maximal work on cycle ergometer. In the trained sportsmen the erythrocyte count and hematocrit value were higher already before exercise. During the exercise the increase in these values, as well as the rise in erythrocyte and serum lactic acid levels were again greater than in untrained freshmen. This difference was caused by the fact that the trained sportsmen performed twice as much work. Glucose utilization by erythrocytes (in vitro) was greatest after maximal exercise in both groups. The differences observed between both groups became manifest during exercise with a greater rise in glucose utilization by the erythrocytes obtained from the trained group. Fifteen minutes after the exercise this utilization fell in both groups below the value obtained before exercise. During the same time erythrocyte count and hematocrit returned to their initial levels.

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64 Tomasik M, "Physical Exercise Effect on Erythrocyte Metabolism" Acta Physiological Polonica 1979 Sep-Dec, 30(5-6) 633-8 Print
Jacobs P L, Nash M S, Rusnowski J W (2001) conducted a study related to the Circuit training provides cardiorespiratory and strength benefits in persons with paraplegia. This study tested the safety and the effects of circuit resistance training (CRT) on peak upper extremity cardiorespiratory endurance and muscle strength in chronic survivors of paraplegia due to spinal cord injury. Methods Ten men with chronic neurologically complete paraplegia at the T5-L1 levels participated in the study. Subjects completed 12 wk of CRT, using a series of alternating isoinertial resistance exercises on a multi-station gym and high-speed, low-resistance arm ergometry. Peak arm ergometry tests, upper extremity isoinertial strength testing, and testing of upper extremity isokinetic strength were all performed before and after training. None of the subjects suffered injury from exercise training. Significant increases were observed in peak oxygen consumption (29.7%, $P < 0.01$), time to fatigue ($P < 0.01$), and peak power output during arm testing ($P < 0.05$). Significant increases in isoinertial strength for the training maneuvers ranged from 11.9% to 30% ($P < 0.01$). Significant increases in isokinetic strength were experienced for shoulder joint internal rotation, extension, abduction, adduction, and horizontal adduction ($P < 0.05$). Chronic survivors of paraplegia safely improve their upper extremity cardiorespiratory endurance and muscle strength when undergoing a short-term circuit resistance training program. Gains in fitness and strength exceeded those usually reported after either arm endurance exercise conditioning or strength training in this subject population.

Chata M and Chaouachi A (2008) conducted a study on Effect of concurrent endurance and circuit resistance training on muscular strength and power development. The purpose of this study was to examine the influence of the sequence order of high-intensity endurance training and circuit training on changes in muscular strength and anaerobic power. Forty-eight physical education students (ages, 21.4 +/- 1.3 years) were assigned to 1 of 5 groups: no training controls (C, n = 9), endurance training (E, n = 10), circuit training (S, n = 9), endurance before circuit training in the same session, (E+S, n =

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10), and circuit before endurance training in the same session (S+E, n = 10) Subjects performed 2 sessions per week for 12 weeks. Resistance-type circuit training targeted strength endurance (weeks 1-6) and explosive strength and power (weeks 7-12). Endurance training sessions included 5 repetitions run at the velocity associated with Vo2max (Vo2max) for duration equal to 50% of the time to exhaustion at Vo2max, recovery was for an equal period at 60% Vo2max. Maximal strength in the half squat, strength endurance in the 1-leg half squat and hip extension, and explosive strength and power in a 5-jump test and countermovement jump were measured pre- and post-testing. No significant differences were shown following training between the S+E and E+S groups for all exercise tests. However, both S+E and E+S groups improved less than the S group in 1 repetition maximum (p < 0.01), right and left 1-leg half squat (p < 0.02), 5-jump test (p < 0.01), peak jumping force (p < 0.05), peak jumping power (p < 0.02), and peak jumping height (p < 0.05). The intrasession sequence did not influence the adaptive response of muscular strength and explosive strength and power. Circuit training alone induced strength and power improvements that were significantly greater than when resistance and endurance training were combined, irrespective of the intrasession sequencing.

Takeshima N et al., (2009) conducted a study related to the effect of concurrent aerobic and resistance circuit training on fitness in older adults. The purpose of this study was to determine the physiological effects of a Programmed Accommodating Circuit Exercise (PACE) program consisting of Aerobic Exercise and Hydraulic-Resistance Exercise (HRE) on fitness in older adults. Thirty-five volunteers were randomly divided into two groups [PACE group (PG) 8 men and 10 women, 68.3 (4.9) years, and non-exercise control group (CG) 7 men and 10 women, 68.0 (3.4) years]. The PG participated in a 12-week, 3 days per week supervised program consisting of 10 min warm-up and 30 min of PACE (moderate intensity HRE and aerobic movements at 70% of peak heart rate) followed by 10 min cool-down exercise. PACE increased (P<0.05) oxygen uptake (V(\text{O}(2))) at lactate threshold [PG, pre 0.79 (0.20) 1 min(-1), post 1.02 (0.22) 1 min(-1), 29%, CG, pre 0.87 (0.14) 1 min(-1), post 0.85 (0.15) 1 min(-1), -2%] and at peak V(\text{O}(2))
[PG, pre 1 36 (0 24) 1 min(-l), post 1 56 (0 28) 1 min(-l), 15%, CG, pre 1 32 (0 29) 1 min(-l), post 1 37 (0 37) 1 mm(-l), 4%] in PG measured using an incremental cycle ergometer Muscular strength evaluated by a HRE machine increased at low to high resistance dial settings for knee extension (9-52%), knee flexion (14-76%), back extension (18-92%) and flexion (50-70%), chest pull (6-28%) and press (3-17%), shoulder press (18-31%) and pull (26-85%), and leg press (21%) Body fat (sum of three skinfolds) decreased (16%), and high-density lipoprotein cholesterol (HDLC) increased (10.9 mg dl(-1)) for PG There were no changes in any variables for CG These results indicate that PACE training incorporating aerobic exercise and HRE elicits significant improvements in cardiorespiratory fitness, muscular strength, body composition, and HDLC for older adults Therefore, PACE training is an effective well-rounded exercise program that can be utilized as a means to improve health-related components of fitness in older adults

68Kalle Karelson et al, (1990) conducted a research on the effect of a single-circuit weight-training session on the blood biochemistry of untrained university students The metabolic and hormonal responses to an intensive single-circuit weight-training session were studied in 15 untrained male students The training programme consisted of ten exercises, employing all the large groups of muscles Students performed three circuits using a work-to-rest ratio of 30 s 30 s at 70% of one-repetition maximum The whole programme lasted 30 mm Blood samples were obtained from the anticubital vein 30 mm before exercise, immediately after exercise finished and after 1-h, 6-h, and 24-h periods of recovery The training session produced significant increases in the plasma adrenocorticotropin hormone, cortisol, aldosterone, testosterone, progesterone and somatotropin concentrations The plasma level of insulin and C-peptide remained unchanged The strength exercises caused elevated ratios of cortisol testosterone and cortisol insulin, indicating a prevalence of stimulation of catabolic processes as well as of mobilization of energy reserves but during the recovery period the reverse of this was observed Immediately after exercise the mean lactate concentration was 7.19 mmol 1-1.

SD 0.56, the glucose concentration increased significantly during exercise and decreased rapidly during recovery. The high density lipoprotein-cholesterol increased in 1-h period of recovery compared with the initial level. The concentration of total cholesterol, low density lipoprotein-cholesterol and triglyceride, did not change. Packed cell volume did not change during exercise or recovery.

Kokkinos P F and Femhall B (1999) conducted a research on Physical activity and high density lipoprotein cholesterol levels: what is the relationship? High density lipoprotein cholesterol (HDL-C) levels are strongly, inversely and independently associated with coronary heart disease (CHD). Increased physical activity is associated with reduced CHD mortality. This protection against CHD may partially be explained by the increase in HDL-C levels observed following aerobic exercise training. Many also agree that an exercise threshold needs to be met before such favourable changes in HDL-C metabolism can occur. Most likely, the exercise-induced changes in HDL-C are the result of the interaction amongst exercise intensity, frequency, duration of each exercise session and length of the exercise training period. Although a relative contribution of each exercise component (intensity, duration and frequency) is also likely, it has not been established. There is also substantial support for a dose-response relationship. Favorable changes in HDL-C appear to occur incrementally and reach statistical significance at approximately 7-10 miles per week or 1200 to 1600 kcal. Exercise-induced changes in HDL-C may also be gender dependent. The volume of exercise required to increase HDL-C levels appears to be substantially more for women than men. This perhaps is due to higher HDL-C levels in women at baseline compared with men. However, the many other health benefits derived from increased physical activity should encourage women to participate in regular exercise regardless of the exercise effects on HDL-C levels. A practical approach in prescribing exercise for patients is to use moderate intensity exercises (70 to 80% of predicted maximal heart rate), 3 to 5 times per week, for a total of 7 to 14 miles per week. This is equivalent to approximately 1200 to 1600 kcal per week. Moderate to low intensity exercise should be preferred because such exercise carries a lower risk for cardiac complications. In addition, patients are more likely to
participate and sustain a lower than higher intensity exercise programme. It is also important to recognise that other modes of physical activity can also be encouraged for patients. Such activities should be associated with similar increases in HDL-C levels as long as they meet or exceed the caloric expenditure of 1200 to 1600kcal (7 to 14 miles per week of jogging).

Tolfrey K, Jones A M and Campbell I G (2000) conducted a research on The effect of aerobic exercise training on the lipid-lipoprotein profile of children and adolescents. Longitudinal paediatric population studies have provided evidence that the risk factor theory may be extended to children and adolescents. These studies could assist in identifying individuals at increased coronary risk. Numerous studies have focused on the effects of regular exercise on the paediatric lipoprotein profile, a recognised primary risk factor, with equivocal results. Cross-sectional comparisons of dichotomised groups provide the strongest evidence of an exercise effect. 'Trained' or 'active' children and adolescents demonstrate 'favourable' levels of high density lipoprotein-cholesterol (HDL-C), tracylglycerol, total cholesterol (TC)/HDL-C and low density lipoprotein-cholesterol (LDL-C)/HDL-C, whilst TC is generally unaffected. The evidence regarding LDL-C in these studies is equivocal. A possible self-selection bias means that a cause-effect relationship between exercise and the lipoprotein profile cannot be readily established from this design. Correlational studies are difficult to interpret because of differences in participant characteristics, methods employed to assess peak oxygen uptake and habitual physical activity (HPA), and the statistical techniques used to analyse multivariate data. Directly measured cardiorespiratory fitness does not appear to be related to lipoprotein profiles in the children and adolescents studied to date, although there are data to the contrary. The relationship with HPA is more difficult to decipher. The evidence suggests that a 'favourable' lipoprotein profile may be related to higher levels of HPA, although differences in assessment methods preclude a definitive answer. While few prospective studies exist, the majority of these longitudinal investigations suggest that imposed regular exercise has little, if any, influence on the lipoprotein levels of children and adolescents. However, most prospective studies have several serious methodological
design weaknesses, including low sample size, inadequate exercise training volume and a lack of control individuals. Recent studies have suggested that increases in HDL-C and reductions in LDL-C may be possible with regular exercise. The identification of a dose-response relationship between exercise training and the lipoprotein profile during the paediatric years remains elusive.

Tolfrey K, Jones A M and Campbell I G (2004) conducted a study on lipid-lipoproteins in children: an exercise dose-response study. Purpose of study to study the effect of exercise volume on pre- and early-pubertal children's lipid-lipoprotein profile. Thirty-four children (15 girls) completed 12 wk of exercise training, preceded by a 12-wk control period. Sixteen (7 girls and 9 boys) expended an additional 422 +/- 5 kJ kg BM (LOW, 100 kcal kg), whereas 18 (8 girls and 10 boys) expended an additional 586 +/- 7 kJ g (MOD, 140 kcal kg) as a result of the training program. They all exercised on three nonconsecutive days per week at 80 +/- 1% HRpeak. Exercise duration was individualized to match energy expenditure targets. Plasma TG, TC, and HDL-C were measured precontrol, pretraining, and posttraining. LDL-C, TC/HDL-C, and LDL-C/HDL-C were also calculated. Group mean lipid-lipoprotein concentrations did not change as a result of training energy expenditure in either of the groups (P > 0.05). Dietary composition, habitual physical activity, and body composition were also relatively stable over the intervention period (P > 0.05). In the LOW, but not the MOD group, peak VO2 (mL kg min) tended to increase over the intervention period (P = 0.07). Pearson's product moment correlation analyses indicated that pretraining concentrations of TG, TC, LDL-C, TC/HDL-C, and LDL-C/HDL-C were all related to the small changes seen in the lipid-lipoprotein profile (P < 0.01). Conclusion of the study relieves that additional energy expenditure of 422 or 586 kJ kg, as a direct result of aerobic exercise training over a 12-wk period, did not cause significant alterations in the lipid-lipoprotein profile in pre- and early-pubertal children. This may indicate that the exercise volume was insufficient, the lipoprotein profiles of the majority of children in this study were classified as "desirable," or more likely a combination of these factors.
Durstine J L et al, (2002) conducted a research on lipids, lipoproteins and exercise. Dose-response relationships between exercise training volume and blood lipid changes suggest that exercise can favorably alter blood lipids at low training volumes, although the effects may not be observable until certain exercise thresholds are met. Results of the study shows that Plasma triglyceride reductions are often observed after exercise training regimens requiring energy expenditures similar to those characterized to increase high-density lipoprotein cholesterol (HDL-C). Thresholds established from cross-sectional and longitudinal exercise training studies indicate that 15 to 20 miles/week of brisk walking or jogging, which draw out between 1,200 to 2,200 kcals of energy expenditure per week, is associated with triglyceride reductions of 5 to 38 mg/dL and HDL-C increases of 2 to 8 mg/dL. Exercise training seldom alters total cholesterol and low-density lipoprotein cholesterol (LDL-C) unless dietary fat intake is reduced and body weight loss is associated with the exercise training program, or both. Thus, for most individuals, the positive effects of regular exercise are exerted on blood lipids at low training volumes and accrue so that noticeable differences frequently occur with energy expenditures of 1,200 to 2,200 kcals/week. It has been concluded that it appears that weekly exercise calorie expenditures that meet or exceed the higher end of this range are more likely to produce the desired lipid changes. Regarding hyperlipidemic disorders, the primary means for intervention is pharmacologic, whereas diet modification, weight loss, and exercise, although important, are viewed as adjunctive therapies. Because much is known about the exercise training-induced plasma lipid and lipoprotein modifications as well as the mechanisms responsible for these changes, rehabilitation professionals can better develop a comprehensive medical management plan that optimizes pharmacologic, reduced dietary fat intake, weight loss, and exercise interventions.

Hurley B F (1989) conducted a research on effects of resistive training on lipoprotein-lipid profiles a comparison to aerobic exercise training. A recent surge of cross-sectional and longitudinal studies dealing with resistive training and lipid profiles have produced conflicting results. The majority of cross-sectional studies demonstrate a

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reduced HDL cholesterol level or elevated total cholesterol to HDL ratio in strength trained athletes as compared with endurance trained athletes. Because of selection biases from many of these studies, there is a lack of control for factors that may influence lipids and lipoproteins, such as age, body composition, diet, and anabolic-androgenic steroid use. Most investigators have reported improved lipoprotein-lipid profiles from resistive training programs. However, many of these studies have design flaws or limitations that make their conclusions questionable. The most serious design flaws include the combination of no control group and only one blood sample taken before and after training, the use of subjects who have low risk profiles, and the lack of control for dietary effects. In a recent study in which we attempted to control for these factors, no changes in lipid profiles were observed after 20 wk of resistive training among individuals at risk for coronary heart disease (CHD). A group serving as reference controls who participated in aerobic-type exercise training during the same time period reduced their plasma triglyceride levels but did not alter their cholesterol or lipoprotein levels. No changes in any lipids or lipoproteins were observed in a group of inactive controls. Thus, resistive training does not appear to alter lipoprotein-lipid profiles among individuals at risk for CHD.

Goldberg L, Elliot D L (1985) conducted a study on the effect of physical activity on lipid and lipoprotein levels. There is more than an intuitive link between the adoption of a sedentary lifestyle and an increase in cardiovascular disease. Physical activity has been associated with a reduced incidence of coronary mortality in cross-sectional and prospective studies. However, an independent relationship between exercise, fitness, and the level of total cholesterol, HDL-C, and triglycerides has been difficult to establish. The effects of training on these parameters may occur only as a consequence of alteration in body habitus, diet, smoking, or ethanol and medication use. Evidence to date suggests that persons with higher cholesterol, LDL-C, and triglyceride levels, as well as individuals with lower HDL-C levels, have favorable changes in these measurements after either endurance or resistive exercise training. Mechanisms that include metabolism and catabolism of lipid and lipoproteins have been discussed.

Goldberg L and Elliot D L, "The Effect of Physical Activity on Lipid and Lipoprotein Levels" The Medical Clinics North America 1985 Jan, 69(1) 41-55 Print
finding that self-report of vigorous activity, rather than treadmill time, correlates well 
with favorable lipoprotein levels suggests that performance of physical work, not 
necessarily aerobic training, is responsible for these alterations The exercise dose 
(intensity, duration, frequency) and total time period necessary, as well as mechanism of 
lipid and lipoprotein change, requires further elucidation

Haskell W L (1984) conducted a research on the influence of exercise on the 
concentrations of triglyceride and cholesterol in human plasma Exercise exerts both 
acute and chronic effects on plasma lipid and lipoprotein concentrations Much of the 
triglyceride-lowering effect is an acute response, with the changes in cholesterol having a 
greater chronic component The acute Tg decrease seems to be due to accelerated 
catabolism resulting from increased LPL activity Following exercise, and on a more 
chronic basis, decreased VLDL-Tg synthesis may also occur in response to an increase in 
tissue insulin sensitivity The low body fat content of endurance-trained athletes also 
contributes to lower Tg concentrations, through this same mechanism The magnitude of 
the plasma Tg response to acute or chronic exercise is highly influenced by preexercise 
values decreases in plasma Tg occur only when preexercise values are elevated The 
major exercise effect on plasma cholesterol appears to be an increase in HDL-C as a 
result of endurance training, very likely related to the increase in LPL activity and Tg 
catabolism This response is not always achieved with exercise training, and has been 
especially difficult to demonstrate in previously sedentary women Exercise effects on 
HDL-C may be augmented by weight loss or changes in nutrient intake, but these 
interrelationships are not well established A dose-response relationship exists, with the 
lower threshold influenced by baseline HDL-C values and exercise status The higher 
HDL-C associated with endurance training is the result of increases in the less dense 
HDL2 subfraction, with elevations in both the lipid and protein components Relatively 
small decreases in LDL-C occur with training The biological mechanisms for these 
xercise effects have not been established

75Haskell W L, “The Influence of Exercise on the Concentrations of Triglyceride and Cholesterol 
in Human Plasma” Exercise and Sport Sciences Reviews 1984,12 205-44 Print
Ullrich and Irma H (1987) conducted a research related to the increased HDL-cholesterol levels with a weight lifting program. Weight training regimens are generally thought not to improve cardiovascular function or lipid parameters. To evaluate this further, we studied 25 men before and after supervised weight training three times each week for eight weeks. Mean plasma HDL-cholesterol level increased significantly with training, from 38.8 to 44.1 mg/dl, while calculated LDL-cholesterol decreased from 132 to 121 mg/dl. Triglyceride values were unchanged. Percent fat decreased from 14% to 12.7% (P < 0.05), and muscle mass increased from 32.4 kg before training to 37 kg after training (P < 0.05). Maximal oxygen consumption (VO2max) increased significantly (from 45.2 to 49.2 ml/kg min) during the eight-week period. LDL-cholesterol and triglycerides were negatively correlated with VO2max, but changes in HDL-cholesterol were not accounted for by alterations in VO2max, muscle mass, or percent fat. This study suggests that weight training can be used to increase strength, alter body composition, improve plasma lipids, and enhance cardiovascular function.

LeMura L M et al. (2000) conducted a research on lipid and lipoprotein profiles, cardiovascular fitness, body composition, and diet during and after resistance, aerobic and combination training in young women. The purpose of this study was to evaluate the effects of various modes of training on the time-course of changes in lipoprotein-lipid profiles in the blood, cardiovascular fitness, and body composition after 16 weeks of training and 6 weeks of detraining in young women. A group of 48 sedentary but healthy women [mean age 20.4 (SD 1) years] were matched and randomly placed into a control group (CG, n = 12), an aerobic training group (ATG, n = 12), a resistance training group (RTG, n = 12), or a cross-training group that combined both aerobic and resistance training (XTG, n = 12). The ATG, RTG, and XTG trained for 16 weeks and were monitored for changes in blood concentrations of lipoprotein-lipids, cardiovascular fitness, body composition, and dietary composition throughout a 16 week period of training and 6 weeks of detraining. The ATG significantly reduced blood concentrations of triglycerides (TRI) (P < 0.05) and significantly increased blood concentrations of high-
density lipoprotein-cholesterol (HDL-C) after 16 weeks of training. The correlation between percentage fat and HDL-C was 0.63 (P < 0.05), which explained 40% of the variation in HDL-C, while the correlation between maximal oxygen uptake (VO2max) and HDL-C was 0.48 (P < 0.05), which explained 23% of the variation in HDL-C. The ATG increased VO2max by 25% (P < 0.001) and decreased percentage body fat by 13% (P < 0.05) after 16 weeks. Each of the alterations in the ATG had disappeared after the 6 week detraining period. The concentration of total cholesterol (TC), TRI, HDL-C and low density lipoprotein-cholesterol in the blood did not change during the study in RTG, XTG and CG. The RTG increased upper and lower body strength by 29% (P < 0.001) and 38%, respectively. The 6 week detraining strength values obtained in RTG were significantly greater than those obtained at baseline. The XTG increased upper and lower body strength by 19% (P < 0.01) and 25% (P < 0.001), respectively. The 6 week detraining strength values obtained in XTG were significantly greater than those obtained at baseline. The RTG, XTG and CG did not demonstrate any significant changes in either VO2max, or body composition during the training and detraining periods. The results of this study suggest that aerobic-type exercise improves lipoprotein-lipid profiles, cardiorespiratory fitness and body composition in healthy, young women, while resistance training significantly improved upper and lower body strength only.

Billat L V (2001) conducted a study on Interval training for performance - a scientific and empirical practice. Special recommendations for middle and long distance running. Part II anaerobic interval training. Studies of anaerobic interval training can be divided into 2 categories. The first category (the older studies) examined interval training at a fixed work-rate. They measured the time limit or the number of repetitions the individual was able to sustain for different pause durations. The intensities used in these studies were not maximal but were at about 130 to 160% of maximal oxygen uptake (VO2max). Moreover, they used work periods of 10 to 15 seconds interrupted by short rest intervals (15 to 40 seconds). The second category (the more recent studies) asked the participants to repeat maximal bouts with different pause durations (30 seconds to 4 to 5
minutes) These studies examined the changes in maximal dynamic power during successive exercise periods and characterised the associated metabolic changes in muscle. Using short-interval training, it seems to be very difficult to elicit exclusively anaerobic metabolism. However, these studies have clearly demonstrated that the contribution of glycogenolysis to the total energy demand was considerably less than that if work of a similar intensity was performed continuously. However, the latter studies used exercise intensities that cannot be described as maximal. This is the main characteristic of the second category of interval training performed above the minimal velocity associated with VO2max determined in an incremental test (vVO2max). Many studies on the long term physiological effect of supramaximal intermittent exercise have demonstrated an improvement in VO2max or running economy.

Ghanbari-Niaki A, Kraemer RR and Soltan R (2010) conducted a study related to the plasma nesfatin-1 and glucoregulatory hormone responses to two different anaerobic exercise sessions. Nesfatin-1 is a recently discovered anorectic protein derived from posttranslational processing of the nucleobindin 2 (NUCB2) gene. It is expressed in adipose tissue and is also found in plasma. Nesfatin-1 expression is significantly affected by nutritional status and its actions may be involved in the inhibition of the orexigenic effect of ghrelin. Although the effects of physical exercise on several anorectic and orexigenic hormones have been reported, no studies have investigated its effects upon circulating concentrations of nesfatin-1. Researchers investigated the effects of acute strenuous interval exercise and circuit exercise on nesfatin and other hormones affected by metabolic stress. Fourteen provincial and national level young male-kickboxing volunteers participated [age 20.71 ± 2.6 years, height 176.6 ± 2.8 cm, body weight 67.2 ± 3.3 kg, and body mass index (BMI) 21.56 ± 1.42 kg/m²]. After an overnight fast, responses to a running-based anaerobic sprint test (RAST, 7 sets of 6 × 35 m every 10 s with 1 min rest in between sets) and a non-combat kickboxing session (NCKB, 7 sets of 6 techniques, 20 s per technique with 1 min rest in between sets) were determined. Venous blood samples were collected before, immediately after, and 45 as well as 95 min after the exercise sessions.
following the exercises Plasma GH, insulin, glucose and lactate concentrations significantly increased immediately following the RAST and NCKB protocols, however, plasma nesfatin-1 concentrations were not significantly altered. Higher plasma cortisol and glucose concentrations occurred in response to the RAST compared with the NCKB protocols. Although the exercise protocols elicited metabolic stress that significantly altered circulating glucoregulatory hormones, plasma glucose and lactate, there was no significant change in plasma nesfatin-1. A lack of nesfatin-1 response to the exercise protocols may be partially due to the fasting condition.

**Brenner et al.** (1999) conducted a study related to the impact of three different types of exercise on components of the inflammatory response. That study was hypothesized that muscle injury would be greater with eccentric than with all-out or prolonged exercise and that immune changes might provide an indication that supplements the information provided by traditional markers such as creatine kinase (CK) or delayed-onset muscle soreness. Eight healthy males [mean (SE) age = 24.9 (2.3) years, maximum oxygen consumption (VO2(max)) = 43.0 (3.1) ml x kg(-1) x min(-1)] were each assigned to four experimental conditions, one at a time, using a randomized-block design. 5 min of cycle ergometer exercise at 90% VO2(max) (AO), a standard circuit-training routine (CT), 2 h cycle ergometer exercise at 60% VO2(max) (Long), or remained seated for 5 h. Blood samples were analyzed for CK, natural killer (NK) cell counts (CD3(-)/CD16(+)/56(+)), cytolytic activity and plasma levels of the cytokines interleukin (IL)-6, IL-10, and tissue necrosis factor alpha (TNF-alpha). CK levels were only elevated significantly 72 h following CT. NK cell counts increased significantly during all three types of exercise, but returned to pre-exercise baseline values within 3 h of recovery. Cytolytic activity per NK cell was not significantly modified by any type of exercise. Prolonged exercise induced significant increases in plasma IL-6 and TNF-alpha. We conclude that the lack of correlation between traditional markers of muscle injury (plasma CK concentrations and muscle soreness rankings) and immune markers of the inflammatory response suggests that, for the types and intensities of exercise examined in

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this study, the exercise-induced inflammatory response is modified by humoral and cardiovascular correlates of exercise.

Durstine J L et al., (2001) conducted a study on Blood lipid and lipoprotein adaptations to exercise: a quantitative analysis. Dose-response relationships between exercise training volume and blood lipid changes suggest that exercise can favourably alter blood lipids at low training volumes, although the effects may not be observable until certain exercise thresholds are met. The thresholds established from cross-sectional literature occur at training volumes of 24 to 32 km (15 to 20 miles) per week of brisk walking or jogging and elicit between 1200 to 2200 kcal/wk. This range of weekly energy expenditure is associated with 2 to 3 mg/dl increases in high-density lipoprotein-cholesterol (HDL-C) and triglyceride (TG) reductions of 8 to 20 mg/dl. Evidence from cross-sectional studies indicates that greater changes in HDL-C levels can be expected with additional increases in exercise training volume. HDL-C and TG changes are often observed after training regimens requiring energy expenditures similar to those characterised from cross-sectional data. Training programmes that elicit 1200 to 2200 kcal/wk in exercise are often effective at elevating HDL-C levels from 2 to 8 mg/dl, and lowering TG levels by 5 to 38 mg/dl. Exercise training seldom alters total cholesterol (TC) and low-density lipoprotein-cholesterol (LDL-C). However, this range of weekly exercise energy expenditure is also associated with TC and LDL-C reductions when they are reported. The frequency and extent to which most of these lipid changes are reported are similar in both genders, with the exception of TG. Thus, for most individuals, the positive effects of regular exercise are exerted on blood lipids at low training volumes and accrue so that noticeable differences frequently occur with weekly energy expenditures of 1200 to 2200 kcal/wk. It appears that weekly exercise caloric expenditures that meet or exceed the higher end of this range are more likely to produce the desired lipid changes. This amount of physical activity, performed at moderate intensities, is reasonable and attainable for most individuals and is within the American College of Sports Medicine's currently recommended range for healthy adults.

Halverstadt A et al, (2007) conducted a study on Endurance exercise training raises high-density lipoprotein cholesterol and lowers small low-density lipoprotein and very low-density lipoprotein independent of body fat phenotypes in older men and women. Endurance exercise training improves plasma lipoprotein and lipid profiles and reduces cardiovascular disease risk. However, the effect of endurance exercise training, independent of diet and body fat phenotypes, on plasma lipoprotein subfraction particle concentration, size, and composition as measured by nuclear magnetic resonance (NMR) spectroscopy is not known. We hypothesized that 24 weeks of endurance exercise training would independently improve plasma lipoprotein and lipid profiles as assessed by both conventional and novel NMR measurement techniques. One hundred sedentary, healthy 50- to 75-year-olds following a standardized diet was studied before and after 24 weeks of aerobic exercise training. Lipoprotein and lipid analyses, using both conventional and NMR measures were performed at baseline and after 24 weeks of exercise training. Relative and absolute maximum oxygen consumption increased 15% with exercise training. Most lipoprotein and lipid measures improved with 24 weeks of endurance exercise training, and these changes were consistently independent of baseline body fat and body fat changes with training. For example, with exercise training, total cholesterol, triglycerides, and low-density lipoprotein cholesterol (LDL-C) decreased significantly (2.1 +/- 1.8 mg/dL, P = 0.01, -17 +/- 3.5 mg/dL, P < 0.001, and -0.7 +/- 1.7 mg/dL, P < 0.001, respectively), and high-density lipoprotein cholesterol subfractions (HDL3-C and HDL2-C) increased significantly (1.9 +/- 0.5 mg/dL, P = 0.01, and 1.2 +/- 0.3 mg/dL, P = 0.02, respectively). Particle concentrations decreased significantly for large and small very low-density lipoprotein particles (-0.7 +/- 0.4 nmol/L, P < 0.001, and -1.1 +/- 1.7 nmol/L, P < 0.001, respectively), total, medium, and very small LDL particles (-100 +/- 26 nmol/L, P = 0.01, -26 +/- 7.0 nmol/L, P = 0.04, and -103 +/- 27 nmol/L, P = 0.02, respectively), and small HDL particles (-0.03 +/- 0.4 micromol/L, P = 0.07). Mean very low-density lipoprotein particle size also decreased significantly (-1.7 +/- 0.9 nm, P < 0.001) and mean HDL particle size increased significantly with exercise training (0.1 +/- 0.0 nm, P = 0.04).

Halverstadt A et al, "Endurance Exercise Training Raises High-Density Lipoprotein Cholesterol and lowers Small Low-Density Lipoprotein and Very Low-Density Lipoprotein Independent of Body Fat Phenotypes in Older Men and Women" Metabolism Clinical and Experimental 2007 Apr, 56(4) 444-50 Print
These results show that 24 weeks of endurance exercise training induced favorable changes in plasma lipoprotein and lipid profiles independent of diet and baseline or change in body fat.

Sharp C P and Pearson D R (2010) conducted a study on Amino acid supplements and recovery from high-intensity resistance training. The purpose of this study was to investigate whether short-term amino acid supplementation could maintain a short-term net anabolic hormonal profile and decrease muscle cell damage during a period of high-intensity resistance training (overreaching), thereby enhancing recovery and decreasing the risk of injury and illness. Eight previously resistance trained males were randomly assigned to either a high branched chain amino acids (BCAA) or placebo group. Subjects consumed the supplement for 3 weeks before commencing a fourth week of supplementation with concomitant high-intensity total-body resistance training (overreaching) (3 x 6-8 repetitions maximum, 8 exercises). Blood was drawn prior to and after supplementation, then again after 2 and 4 days of training. Serum was analyzed for testosterone, cortisol, and creatine kinase. Serum testosterone levels were significantly higher (p < 0.001), and cortisol and creatine kinase levels were significantly lower (p < 0.001, and p = 0.004, respectively) in the BCAA group during and following resistance training. These findings suggest that short-term amino acid supplementation, which is high in BCAA, may produce a net anabolic hormonal profile while attenuating training-induced increases in muscle tissue damage. Athletes' nutrient intake, which periodically increases amino acid intake to reflect the increased need for recovery during periods of overreaching, may increase subsequent competitive performance while decreasing the risk of injury or illness.

Ascensao et al., (2008) conducted a study on Biochemical impact of a soccer match - analysis of oxidative stress and muscle damage markers throughout recovery. Exercise is a prone condition to enhanced oxidative stress and damage and the specific activity pattern of a soccer match may favour additional pro-oxidant redox alterations. To date, no studies have reported the impact of a soccer match on oxidative stress and...
muscle damage markers. Main aim is to analyse the effect of a competitive soccer match on plasma levels of oxidative stress and muscle damage markers, and to relate these findings with lower limb functional data. Blood samples, leg muscle strength, sprint ability and delayed-onset muscle soreness (DOMS) were obtained in 16 soccer players before, at 30 min, 24, 48 and 72 h after a soccer match. Plasma creatine kinase (CK), myoglobin (Mb), malondialdehyde (MDA), sulphydryl (-SH) groups, total antioxidant status (TAS), uric acid (UA) and blood leukocyte counts were determined. Results of study are that a soccer match elevated plasma Mb following 30 min and CK levels throughout the 72 h-recovery period. MDA increased throughout the recovery period and -SH decreased until 48 h post-match. TAS increased at 30 min and UA increased throughout the 72 h recovery. Blood neutrophils increased at 30 min whereas lymphocytes decreased and returned to baseline from 24 to 72 h. DOMS was higher than baseline until 72 h. Lower limb strength and sprint ability were lower than baseline until 72 h recovery. Study concluded that the present data suggest that a soccer match increases the levels of oxidative stress and muscle damage throughout the 72 h-recovery period. The extent to which the redox alterations are associated with the recovery of muscle function should be further analysed.

Telford, Richard D, Cunningham and Ross B (1991) conducted a study on sex, sport, and body-size dependency of hematology in highly trained athletes and in this study blood hemoglobin concentration, hematocrit, red cell count, white cell count (WBC), and plasma ferritin concentration were measured on 1604 occasions from 706 nationally ranked athletes in 12 sports. The blood samples were taken from a forearm vein amidst periods of moderate to intense training but at least 6 h after a training session. A multiple regression model, accounting for correlations between variables and incorporating the categorical variables of sex and sport revealed the following: Each blood variable was found to be dependent on body mass index, (mass/height², BMI), with the exception of WBC in the males. As BMI increased so did the magnitude of these blood variables (P < 0.01). Each blood variable was also dependent on the sport (P < 0.01), significant differences being observed between several sports in each case.

Telford, Richard D, Cunningham and Ross B, “Sex, Sport, and Body-Size Dependency of Hematology in Highly Trained Athletes” Medicine & Science in Sports & Exercise 1991 July, 23(7) 788-794 Print
Furthermore, as has been previously reported, the magnitude of the blood variables was dependent on the sex of the athlete, each being significantly greater in males ($P < 0.01$), with the exception of the WBC, which was greater in females ($P < 0.01$). These data indicate that the rationality of interpreting the hematology in highly trained athletes may be increased by taking BMI and sport into account, as well as gender.

86Helgerud J et al, (2001) conducted a study related to the Aerobic endurance training improves soccer performance. The aim of the present study was to study the effects of aerobic training on performance during soccer match and soccer specific tests. Total of Nineteen male elite junior soccer players, age 18.1 +/- 0.8 yr, 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 study resulted that in the training group a) maximal oxygen uptake (VO2max) increased from 58.1 +/- 4.5 mL x kg(-1) x min(-1) to 64.3 +/- 3.9 mL x kg(-1) x min(-1) ($P < 0.01$), b) lactate threshold improved from 47.8 +/- 5.3 mL x kg(-1) x min(-1) to 55.4 +/- 4.1 mL x kg(-1) x min(-1) ($P < 0.01$), c) running economy was also improved by 6.7% ($P < 0.05$), d) distance covered during a match increased by 20% in the training group ($P < 0.01$), e) number of sprints increased by 100% ($P < 0.01$), f) number of involvements with the ball increased by 24% ($P < 0.05$), g) the average work intensity during a soccer match, measured as percent of maximal heart rate, was enhanced from 82.7 +/- 3.4% to 85.6 +/- 3.1% ($P < 0.05$), and h) no changes were found in maximal vertical jumping height, strength, speed, kicking velocity, kicking precision, or quality of passes after the training period. The control group showed no changes in any of the tested parameters. Study has been concluded that enhanced aerobic endurance in soccer players improved soccer performance by increasing the distance covered, enhancing work intensity, and increasing the number of sprints and involvements with the ball during a match.

Leon AS and Sanchez O A (2001) conducted a study on response of blood lipids to exercise training alone or combined with dietary intervention. The main purpose of this study is to review the effects of aerobic exercise training (AET) on blood lipids and assess dose-response relationships and diet interactions. Methods are researcher reviewed papers published over the past three decades pertaining to intervention trials on the effects of > or = 12 wk of AET on blood lipids and lipoprotein outcomes in adult men and women. Included were studies with simultaneous dietary and AET interventions, if they had appropriate comparison groups. Studies were classified by the participants' relative weights expressed as mean BMIs. Information was extracted on baseline characteristics of study subjects, including age, sex, and relative baseline cholesterol levels, details on the training programs, and the responses to training of body weight, VO(2\text{max}), and blood total cholesterol (TC) and low-density lipoprotein-cholesterol (LDL-C), high-density lipoprotein-cholesterol (HDL-C), and triglyceride (TG). Results identified 51 studies, 28 of which were randomized controlled trials. AET was generally performed at a moderate to hard intensity, with weekly energy expenditures ranging from 2,090 to >20,000 kJ. A marked inconsistency was observed in responsiveness of blood lipids. The most commonly observed change was an increase in HDL-C (with reductions in TC, LDL-C, and TG less frequently observed). Insufficient data are available to establish dose-response relationships between exercise intensity and volume with lipid changes. The increase in HDL-C with AET was inversely associated with its baseline level (r = -0.462), but no significant associations were found with age, sex, weekly volume of exercise, or with exercise-induced changes in body weight or VO(2\text{max}).

Conclusion of the study are Moderate- to hard-intensity AET inconsistently results in an improvement in the blood lipid profile, with the data insufficient to establish dose-response relationships.

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Bounds R G, et al, (2000) conducted a study on Diet and short term plasma lipoprotein-lipid changes after exercise in trained men. The study tested the effect of diet on the short-term lipid response to exercise, fourteen moderately trained (VO2max 50.2 +/- 6.7 ml/kg/min), healthy men (mean age 28 +/- 4 years) were alternately fed a high fat (60 +/- 6.7% fat) and a high carbohydrate (63 +/- 3.2% carbohydrate) isoenergetic diet for 2 weeks in a randomized crossover design. During the last 4 days of the treatments, fasting total cholesterol, triglyceride, HDL-cholesterol, and HDL3-cholesterol were measured the day before, and again immediately, 24 hr, and 48 hr after exercise (4190 kJ, 70% VO2max). LDL-cholesterol and HDL2-cholesterol were calculated. Lipid concentrations were adjusted for plasma volume changes after exercise. A 2 (diet) x 4 (time) ANOVA with repeated measures revealed no significant interaction between the diet and exercise treatments. Furthermore, diet alone did not influence lipid concentrations in these trained men. Exercise resulted in an increase in HDL-C (10.7%) and HDL3-C (8.5%) concentrations and a concomitant fall in triglyceride (-25%) and total cholesterol (-3.5%). Thus, we conclude that diet composition does not affect the short-term changes in blood lipids and lipoproteins that accompany a single session of aerobic exercise in moderately trained men.

Smirnova T et al, (1990) conducted a research on the effect of a single-circuit weight-training session on the blood biochemistry of untrained university students. The metabolic and hormonal responses to an intensive single-circuit weight-training session were studied in 15 untrained male students. The training programme consisted of ten exercises, employing all the large groups of muscles. Students performed three circuits using a work-to-rest ratio of 30 s 30 s at 70% of one-repetition maximum. The whole programme lasted 30 min. Blood samples were obtained from the antecubital vein 30 min before exercise, immediately after exercise finished and after 1-h, 6-h, and 24-h periods of recovery. The training session produced significant increases in the plasma adrenocorticotropic hormone, cortisol, aldosterone, testosterone, progesterone, and...
somatotropin concentrations The plasma level of insulin and C-peptide remained unchanged. The strength exercises caused elevated ratios of cortisol testosterone and cortisol insulin, indicating a prevalence of stimulation of catabolic processes as well as of mobilization of energy reserves, but during the recovery period the reverse of this was observed. Immediately after exercise the mean lactate concentration was 7.19 mmol l⁻¹, SD 0.56, the glucose concentration increased significantly during exercise and decreased rapidly during recovery. The high density lipoprotein-cholesterol increased in 1-h period of recovery compared with the initial level. The concentration of total cholesterol, low density lipoprotein-cholesterol and triglyceride, did not change. Packed cell volume did not change during exercise or recovery.

Almar M et al. (2009) conducted a study on Cytokine and hormone responses to resistance training. This study examined the effects of heavy resistance training on physiological acute exercise-induced fatigue (5 x 10 RM leg press) changes after two loading protocols with the same relative intensity (%) (5 x 10 RM(Rel)) and the same absolute load (kg) (5 x 10 RM(Abs)) as in pretraining in men (n = 12). Exercise-induced neuromuscular (maximal strength and muscle power output), acute cytokine and hormonal adaptations (i.e., total and free testosterone, cortisol, growth hormone (GH), insulin-like growth factor-1 (IGF-1), IGF binding protein-3 (IGFBP-3), interleukin-1 receptor antagonist (IL-1ra), IL-1beta, IL-6, and IL-10 and metabolic responses (i.e., blood lactate) were measured before and after exercise. The resistance training induced similar acute responses in serum cortisol concentration but increased responses in anabolic hormones of FT and GH, as well as inflammation-responsive cytokine IL-6 and the anti-inflammatory cytokine IL-10, when the same relative load was used. This response was balanced by a higher release of pro-inflammatory cytokines IL-1beta and cytokine inhibitors (IL-1ra) when both the same relative and absolute load was used after training. This enhanced hormonal and cytokine response to strength exercise at a given relative exercise intensity after strength training occurred with greater accumulated fatigue and metabolic demand (i.e., blood lactate accumulation). The magnitude of metabolic demand or the fatigue experienced during the resistance exercise session.
influences the hormonal and cytokine response patterns. Similar relative intensities may elicit not only higher exercise-induced fatigue but also an increased acute hormonal and cytokine response during the initial phase of a resistance training period.

Umeda T et al., (2008) conducted a study on the effects of a two hour judo training session on the neutrophil immune functions in university judoists and the present study examined the effects of judo training on neutrophil and related functions. We measured and studied changes in the neutrophil and its related functions in 22 male university judoists immediately before (Pre values) and immediately after (Post values) a 2 h training session. Reactive oxygen species (ROS) production capability, phagocytic activities (PA) and serum opsonic activity (SOA). Neutrophil count in whole blood, myogenic enzymes (creatine kinase, lactate dehydrogenase, aspartate aminotransferase and alanine aminotransferase), immunoglobulins (IgG, IgA and IgM) and complements (C3 and C4) in serum were also measured. The Post values of the neutrophil count, myogenic enzymes and IgG increased significantly compared with the Pre values. ROS production capability and SOA also significantly increased following training, although PA showed a slight decrease (but not statistically significant). Taking the findings of our previous studies into consideration, three major neutrophil or related functions, namely ROS production capability, PA and SOA, might compensate for each other to maintain the overall integrity of the neutrophil immune function, in that ROS and SOA increased to compensate for the slight decrease in PA, or PA slightly decreased to compensate for the increase in ROS and SOA after exercise.

Franklin M E, Cumer D and Franklin R C (1991) conducted a research on the Effect of One Session of Muscle Soreness-Inducing Weight Lifting Exercise on WBC Count, Serum Creatine Kinase, and Plasma Volume. The purpose of this study was to assess white blood cell (WBC) count, serum creatine kinase (CK), and plasma volume (PV) changes following a single session of soreness-inducing exercise. Sixteen untrained

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Umeda T et al., “Effects of a Two Hour Judo Training Session on the Neutrophil Immune Functions in University Judoists” Luminescence. The Journal of Chemical and Biological Luminescence. 2008 Jan-Feb, 23(1) 49-43 Print

males, aged 18 to 38 years, were exercised at 80% of one repetition maximum until
failure for three sets on seven different weight lifting resistive machines. Measurements
were done prior to and up to 84 hours postexercise on a) delayed onset muscle soreness
(DOMS), utilizing a four-point pain scale on seven muscles, b) CK, c) WBC count, and
d) PV change, indirectly assessed by hematocrit and hemoglobin. One session of weight
lifting exercise was found to produce significant postexercise PV elevations, with the
peak change occurring at 36 hours (8.9%, p < .05). Significant elevations in WBC count
were found 12 hours postexercise (7900 cells/ml, p < .05) when corrections were made
for PV increases. In addition, DOMS and CK were significantly increased postexercise,
with the highest levels occurring at 36 hours (9.21 pain scale units, p < .05) and 84 hours
(5756 IU/L, p < .001). These results suggest that one session involving high intensity
weight lifting exercise may induce muscle soreness and elevate WBC count, CK, and
plasma volume. The aggressive initiation of a fitness program can trigger delayed muscle
discomfort, a possible inflammatory process, and dilate blood parameters that physical
therapists may be monitoring.

Craig S K, Byrnes W C and Fleck S J (2008) conducted a study on Plasma
volume during weight lifting. The study relieved that the magnitude and pattern of the
hematocrit (Hct), hemoglobin (Hb), and plasma volume (PV) responses during and upon
recovery from two resistance training protocols based on either a ten-repetition maximum
(10 RM) or five-repetition maximum (5 RM) resistance was examined. Twelve college-
aged male resistance exercise trainers were equally divided between the protocols and
performed at least four workouts prior to testing to determine the 10 RM or 5 RM for
each exercise set. Each protocol included three sets of nine exercises. The 10-RM session
used one-minute rest periods between sets, and two minutes between exercises. The 5-
RM session employed three-minute rest periods between sets and exercises. A catheter
inserted in the forearm allowed for venous blood sampling after twenty minutes supine
rest, the last set of each exercise, and at fifteen and thirty minutes of recovery. Control
conditions were included for posture (P) and limb motion (U) Loaded exercise (L) was
significantly different from U and P controls for Hct, Hb, and PV responses. For 10 RM

Craig S K, Byrnes W C and Fleck S J. "Plasma Volume during Weight Lifting." International
Journal of Sports Medicine 2008 Feb, 29(2) 89-95. Print
and 5 RM respectively, the mean change from rest was 6.2 (+/- 0.9) and 3.5 (+/- 0.4) % for Hct, 2.2 (+/- 0.2) and 1.2 (+/- 0.1) gm/dl for Hb, and -22.6 (+/- 2.3) and -13.0 (+/- 1.2) % for PV. The main effect for protocol was significant for Hct (p = 0.0006) and Hb (p = 0.0033), with 10-RM changes being greater than 5 RM. The greatest increase in Hct and Hb occurred after the first set for both protocols. An increase in Hct and Hb during the protocol was observed for the 10 RM, but not the 5 RM. During recovery, Hct and Hb were elevated above rest for 10 RM, but not 5 RM. PV decreases mirrored Hct and Hb in pattern of change and significance. The data demonstrate that magnitude and pattern of Hct, Hb, and PV was dependent on the type of resistance training protocol.

Boone J. B. et al. (1990) conducted a study on resistance exercise effects on plasma cortisol, testosterone and creatine kinase activity in anabolic-androgenic steroid users. Anabolic-androgenic steroids (AS) users have been reported to have an improved ability to withstand exhaustive resistance workouts and to recover more rapidly. The purpose of this investigation was to study the effects of AS usage on the cortisol (C), testosterone (T) and creatine kinase (CK) response to a resistance training session. Eleven trained bodybuilders and powerlifters (5.0 +/- 1.16 training years, mean +/- SD), 5 AS users (SU) and 6 nonusers (NU), completed a standardized resistance training session consisting of 10 sets of back squats at preset percentages of the subject's 1 RM max. Blood samples were obtained at rest, immediately post exercise and 24 hours after the exercise session. SU had significantly lower T at rest. Neither group exhibited a significant change in T at 1 min or at 24 h post exercise. Both the NU and SU exhibited a significant increase in CK at 1 min post exercise (129 +/- 23 U/l-1, 81 +/- 15 U/l-1, respectively), with the NU response significantly greater than the SU. After 24 h, CK for NU was significantly elevated (1719 +/- 54.5 U/l-1) above resting level. In contrast, CK for SU had returned to resting level. NU had a significant increase in cortisol (C) (p < 0.05) at 1 min post exercise (156.8 +/- 10.9 nmol/l-1), while the SU cortisol was not significantly changed. By 24 h C for the NU returned to resting level. The results of this investigation support the concept that AS users have a diminished CK response and an altered stress response to a single bout of resistance exercise.

Lukaski H C (2001) conducted a study on Magnesium, zinc and chromium nutrition and athletic performance. Magnesium, zinc and chromium are mineral elements required in modest amounts for health and optimal performance. Accumulating evidence supports the hypothesis that magnesium and zinc play significant roles in promoting strength and cardiorespiratory function in healthy persons and athletes. Differences in study designs, however, limit conclusions about recommendations for intakes of magnesium and zinc needed for optimal performance and function. The role of chromium in supporting performance is not well established. There is a compelling need to confirm and extend findings of beneficial effects of magnesium and zinc function and performance of humans. Suggestions for an experimental model and specific topics for research to advance knowledge of mineral nutrition to promote attainment of genetic potential for optimal performance are provided.

Nielsen F H and Lukaski H C (2006) conducted a study on the update on the relationship between magnesium and exercise. Magnesium is involved in numerous processes that affect muscle function including oxygen uptake, energy production and electrolyte balance. Thus, the relationship between magnesium status and exercise has received significant research attention. This research has shown that exercise induces a redistribution of magnesium in the body to accommodate metabolic needs. There is evidence that marginal magnesium deficiency impairs exercise performance and amplifies the negative consequences of strenuous exercise (e.g., oxidative stress). Strenuous exercise apparently increases urinary and sweat losses that may increase magnesium requirements by 10-20%. Based on dietary surveys and recent human experiments, a magnesium intake less than 260 mg/day for male and 220 mg/day for female athletes may result in a magnesium-deficient status. Recent surveys also indicate that a significant number of individuals routinely have magnesium intakes that may result in a deficient status. Athletes participating in sports requiring weight control (e.g., wrestling, gymnastics) are apparently especially vulnerable to an inadequate magnesium intake.
status. Magnesium supplementation or increased dietary intake of magnesium will have beneficial effects on exercise performance in magnesium-deficient individuals. Magnesium supplementation of physically active individuals with adequate magnesium status has not been shown to enhance physical performance. An activity-linked RNI or RDA based on long-term balance data from well-controlled human experiments should be determined so that physically active individuals can ascertain whether they have a magnesium intake that may affect their performance or enhance their risk to adverse health consequences (e.g., immunosuppression, oxidative damage, arrhythmias).

Bohl C H and Volpe S L (2002) conducted a study on magnesium and exercise. Magnesium is an essential element that regulates membrane stability and neuromuscular, cardiovascular, immune, and hormonal functions and is a critical cofactor in many metabolic reactions. The Dietary Reference Intake for magnesium for adults is 310 to 420 mg/day. However, the intake of magnesium in humans is often suboptimal. Magnesium deficiency may lead to changes in gastrointestinal, cardiovascular, and neuromuscular function. Physical exercise may deplete magnesium, which, together with a marginal dietary magnesium intake, may impair energy metabolism efficiency and the capacity for physical work. Magnesium assessment has been a challenge because of the absence of an accurate and convenient assessment method. Recently, magnesium has been touted as an agent for increasing athletic performance. This article reviews the various studies that have been conducted to investigate the relationship of magnesium and exercise.

Laires M J and Monteiro C (2008) conducted a study on Exercise, Magnesium and Immune Function. Physical exercise may deplete magnesium, which together with a marginal dietary magnesium intake may impair energy metabolism, muscle function, oxygen uptake, and electrolyte balance. Consequently, the ability to perform physical work may be compromised. Many aspects of immune function can be depressed temporarily by either a single bout of very severe exercise or a longer period of excessive training. Although the disturbance is usually quite transient, it can be sufficient to allow a clinical episode of infection, particularly upper respiratory tract infections. However,

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Bohl C H and Volpe S L “Magnesium and Exercise” Critical Reviews in Food Science Nutrition 2002, 42(6) 533-63
regular and moderate exercise has been reported to improve the ability of the immune system to protect the host from infection. Magnesium also has a strong relation with the immune system in both non-specific and specific immune responses and magnesium deficit has been shown to be related to impaired cellular and humoral immune function. Magnesium deficiency leads to immunopathological changes that are related to the initiation of a sequential inflammatory response. Although in athletes magnesium deficiency has not been investigated regarding alterations in the immune system, the possibility exist that magnesium deficiency could contribute to the immunological changes observed after strenuous exercise.

Manuel Gimenez et al., conducted a study on Serum iron and transferrin during an exhaustive session of interval training. Conflicting data have been reported on "sports anaemia" and anaemia during physical training. Most of these results are of studies at rest before or after training. The aim of this investigation was to further study the profiles of serum iron (Se Fe) and transferrin (Se Tr), in 14 physically trained men (28±6 years) during an exhaustive interval training session. The 45 min Square-Wave Endurance Exercise Test (SWEET) was performed on a cycle ergometer. To the SWEET base, established as a % of individual Vo2max, a peak of 1 min at Vo2max was added every 5 minutes. Arterial blood samples were taken at rest, during the SWEET at the 14th, 15th, 29th, 30th, 44th and 45th minutes, just before and after the peaks, and at the 15th min of recovery. Lactate, acidity [H+], PaCO2, PaO2, Haematocrit (Hct), Haemoglobin (Hb), Se Fe and Se Tr were measured. After the SWEET, weight loss was 0.89±0.15 kg. Lactate and serum iron rose progressively at the base levels and at the peaks, while PaCO2 and bicarbonate fell progressively. Hct, [Hb], serum transferrin and [H+] increased significantly at the 14th min of SWEET and thereafter no change was observed. At the 45th min with respect to the value at rest, Se Fe increased as much as +32%, Se Tr +13% and [Hb] +8%. Haemoconcentration could explain the changes in Se Tr but not the total significant increase in Se, Fe, which moreover is not explained by acidosis [H+]. If serum transferrin was saturated, the transitory iron changes during SWEET would make way for...

a readily available iron reserve for synthesis of myoglobin, and moreover it is probable that a certain quantity of iron lost in the sweat and in the urine could explain the iron deficiency observed with training programmes.

Robert F Chapman, James Stray-Gundersen, and Benjamin D Levine (1998) conducted a research on individual variation in response to altitude training. The study itself explains moderate-altitude living (2,500 m), combined with low-altitude training (1,250 m) (i.e., live high-train low), results in a significantly greater improvement in maximal \( O_2 \) uptake (\( VO_{2\text{max}} \)) and performance over equivalent sea-level training. Although the mean improvement in group response with this "high-low" training model is clear, the individual response displays a wide variability. To determine the factors that contribute to this variability, 39 collegiate runners (27 men, 12 women) were retrospectively divided into responders \( (n = 17) \) and nonresponders \( (n = 15) \) to altitude training on the basis of the change in sea-level 5,000-m run time determined before and after 28 days of living at moderate altitude and training at either low or moderate altitude. In addition, 22 elite runners were examined prospectively to confirm the significance of these factors in a separate population. In the retrospective analysis, responders displayed a significantly larger increase in erythropoietin (Epo) concentration after 30 h at altitude compared with nonresponders. After 14 days at altitude, Epo was still elevated in responders but was not significantly different from sea-level values in nonresponders. The Epo response led to a significant increase in total red cell volume and \( VO_{2\text{max}} \) in responders, in contrast, nonresponders did not show a difference in total red cell volume or \( VO_{2\text{max}} \) after altitude training. Nonresponders demonstrated a significant slowing of interval-training velocity at altitude and thus achieved a smaller \( O_2 \) consumption during those intervals, compared with responders. The acute increases in Epo and \( VO_{2\text{max}} \) were significantly higher in the prospective cohort of responders, compared with nonresponders, to altitude training. In conclusion, after a 28-day altitude training camp, a significant improvement in 5,000-m run performance is, in part, dependent on (1) living at a high enough altitude to achieve a large acute increase in Epo, sufficient to increase the
total red cell volume and $VO_2^{max}$, and 2) training at a low enough altitude to maintain interval training velocity and $O_2$ flux near sea-level values.

There is a tendency to refer to training programmes in very black and white terms, as either ‘training’ or ‘overtraining’, and then attempt to identify the boundary which is supposed to exist between the two states. Perhaps it would be helpful to recognize that a grey scale is more likely to exist. Any training session will displace the homeostasis of the body, resulting in a number of catabolic events. These may include the breakdown of structural and functional proteins and the utilization of endogenous energy stores. Consequently, a single training session will result in a certain level of fatigue, changes in biochemical, hormonal and immunological measures and a temporary reduction of an athlete’s performance. A recovery period is then required, during which time the body works to re-establish homeostasis, replenish endogenous energy stores, synthesize new protein and restore performance capacity. An athlete’s performance at any given time will be determined by the combination and distribution of previous training sessions and recovery periods. Any imbalance between training and recovery, whether over a number of months, a few weeks or even a couple of days, will produce the characteristic impairment in physical performance which we refer to as overtraining. Distinguishing between each situation may not be possible on the basis of performance capacity, or biochemical, hormonal or other variables, but only in terms of the time required to regain peak performance.

Indramil Manna, Gulshan Lal Khanna and Prakash Chandra Dhara (2010) conducted a study on age-related changes in selected morphological, physiological and biochemical variables of Indian field hockey players. The aim of the present study was to find out the age-related changes in selected morphological, physiological and biochemical variables of Indian field hockey players. One hundred and twenty ($N = 120$) field hockey players volunteered for this study. The players were divided equally into four groups ($n=30$) under 16 years (U16), under 19 years (U19), under 23 years (U23)...

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and seniors (SR) Height, body mass, body fat, lean body mass (LBM), VO₂max, anaerobic power, strength, hemoglobin (Hb), serum urea, uric acid, total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) were measured in the laboratory. Analysis of variance with repeated measures followed by multiple comparison tests was performed to find out the significant difference in selected morphological, physiological and biochemical parameters among the selected age groups. Results showed significantly higher (p<0.05) body mass, height, LBM, anaerobic power, strength, Hb, serum urea, uric acid, TC, TG, HDL-C and LDL-C in the U23 and senior players compared with those in U16 and U19 players. However, significantly (p<0.05) lower body fat was noted in U16 and U19 players as compared with those in U23 and senior age group players. It was observed that VO₂max elevated significantly (p<0.05) in U19 age group players, then declined (p<0.05) further in the senior age group players. The present study can be a handy tool and can act as a frame of reference for selection of field hockey players of different age groups.

Laursen P B and Jenkins D G (2002) conducted a study on the scientific basis for high-intensity interval training optimising training programmes and maximising performance in highly trained endurance athletes. While the physiological adaptations that occur following endurance training in previously sedentary and recreationally active individuals are relatively well understood, the adaptations to training in already highly trained endurance athletes remain unclear. While significant improvements in endurance performance and corresponding physiological markers are evident following submaximal endurance training in sedentary and recreationally active groups, an additional increase in submaximal training (i.e., volume) in highly trained individuals does not appear to further enhance either endurance performance or associated physiological variables [e.g., peak oxygen uptake (VO₂peak), oxidative enzyme activity]. It seems that, for athletes who are already trained, improvements in endurance performance can be achieved only through high-intensity interval training (HIT). The limited research which has examined changes...
in muscle enzyme activity in highly trained athletes, following HIT, has revealed no change in oxidative or glycolytic enzyme activity, despite significant improvements in endurance performance (p < 0.05) Instead, an increase in skeletal muscle buffering capacity may be one mechanism responsible for an improvement in endurance performance Changes in plasma volume, stroke volume, as well as muscle cation pumps, myoglobin, capillary density and fibre type characteristics have yet to be investigated in response to HIT with the highly trained athlete Information relating to HIT programme optimisation in endurance athletes is also very sparse Preliminary work using the velocity at which VO2max is achieved (V(max)) as the interval intensity, and fractions (50 to 75%) of the time to exhaustion at V(max) (T(max)) as the interval duration has been successful in eliciting improvements in performance in long-distance runners However, V(max) and T(max) have not been used with cyclists Instead, HIT programme optimisation research in cyclists has revealed that repeated supramaximal sprinting may be equally effective as more traditional HIT programmes for eliciting improvements in endurance performance Further examination of the biochemical and physiological adaptations which accompany different HIT programmes, as well as investigation into the optimal HIT programme for eliciting performance enhancements in highly trained athletes is required

Brites F D et al, (1999) conducted a study on the Soccer players under regular training show oxidative stress but an improved plasma antioxidant status Physical activity is known to induce oxidative stress in individuals subjected to intense exercise In this study, we investigated the lipoprotein profile and the plasma antioxidant status in a group of soccer players engaged in a regular training programme As was expected for aerobic exercise, high-density lipoprotein-cholesterol (HDL-C) and HDL3-C levels were significantly increased in the sportsmen (P<0.05) Total plasma antioxidant capacity was 25% higher in sportsmen than in controls (P<0.005) Accordingly, plasma hydrosoluble antioxidant levels (ascorbic acid and uric acid) were found to be significantly elevated in the soccer players (P<0.005) In addition, these subjects showed high concentrations of alpha-tocopherol in plasma compared with controls (P<0.005) Furthermore, an increase

in plasma superoxide dismutase activity was also observed in relation to exercise (P<0.01). The elevation in plasma activities of antioxidant enzymes and the higher levels of free radical scavengers of low molecular mass may compensate the oxidative stress caused by physical activity. High levels of high-density lipoprotein in plasma may offer additional protection by inhibiting low-density lipoprotein oxidation and thus lipo-soluble antioxidant consumption. Therefore, soccer players under regular training show an improved plasma antioxidant status in comparison to sedentary controls.

105Cadefau J et al, (1990) conducted a study on the Biochemical and histochemical adaptation to sprint training in young athletes. The purpose of the present study was to investigate the effects of 8 months of a specific and controlled sprint training programme on three groups of young athletes (two groups of males and one of females). Biopsies of vastus lateralis were taken before and after the period of training. The type percentage and diameter of the fibres, as well as the glycogen content and the activities of the enzymes of glycogen metabolism (glycogen synthase and glycogen phosphorylase), glycolysis (phosphofructokinase, pyruvate kinase, aldolase and lactate dehydrogenase), oxidative metabolism (succinate dehydrogenase) and creatine kinase and aminotransferases were studied. The results show an increase in the percentage of type I fibres and an increase in the diameter of both fibre types. A significant increase was also observed in glycogen content, and in the activities of glycogen synthase, glycogen phosphorylase, phosphofructokinase, pyruvate kinase, succinate dehydrogenase, aspartate aminotransferase and alanine aminotransferase. Study concluded that a long period of sprint training induces a biochemical muscle adaptation to anaerobic exercise. This metabolic adaptation is followed by a morphological adaptation, although this is probably not as specific as the biochemical one.

106Leyre Gravina et al, (2011) conducted a study on the metabolic impact of a soccer match on female players and the aim of this study was to examine the metabolic effect of a female soccer match in elite and sub-elite teams. Blood samples were taken (24 h before, immediately after and 18 h after official soccer matches) to determine haematological, biochemical and metabolic parameters.
electrolytic and hormonal variables, as well as the levels of cell damage and oxidative stress in 14 elite and 14 sub-elite players. Our results show increases in white blood cell count ($P < 0.001$) and the percentage of neutrophils ($P < 0.001$), and decreases in the percentage of lymphocytes ($P < 0.05$), eosinophils ($P < 0.001$), monocytes ($P < 0.001$) and basophils ($P < 0.05$) immediately post-match. Increases were also found in lactate dehydrogenase activity ($P < 0.001$), uric acid ($P < 0.001$), albumin ($P < 0.001$), total antioxidant status ($P < 0.001$) and free testosterone levels ($P < 0.01$). Creatine kinase activity significantly increased 18 h post-match ($P < 0.01$) and the concentrations of several ions, glucose and proteins were found to be altered immediately post-match. Overall, our results show that playing a soccer match exerts specific metabolic effects on female players, resulting in muscle damage, oxidative stress and biochemical and hormonal variations. On the basis of some interesting correlations, we also suggest that exercise-induced cell breakdown may enhance antioxidant capacity of the soccer players.

Takarada Y (2003) conducted a research on evaluation of muscle damage after a rugby match with special reference to tackle plays. The main objective of concerned study is to investigate blood indices of muscle damage after a competitive rugby match. Fifteen elite amateur rugby players volunteered to participate (mean (SE) age 26.6 (0.7) years, height 179.8 (1.0) cm, weight 87.4 (2.2) kg, and VO2 MAX 58.5 (1.2) ml/kg/min). The study was conducted after two competitive matches during the 1999–2000 seasons. Plasma concentrations of lactate, potassium ($K^+$), sodium ($Na^+$), and myoglobin, and the activity of creatine kinase were measured before and after the matches. In addition, the number of tackles by and on each subject and the average duration of the work and rest periods were analysed using video recordings of the matches. Myoglobin concentration and creatine kinase activity showed appreciable transient increases after the match. Peak values for myoglobin concentration (980 (166) μg/l) and creatine kinase activity (1081 (159) U/l) were observed 45 minutes and 24 hours after the match respectively. Positive and significant correlations were observed between the number of tackles and both peak myoglobin concentration ($r = 0.85$, $p<0.01$, $n = 14$) and peak creatine kinase activity ($r =$

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Takarada Y “Evaluation of Muscle Damage after a Rugby Match with Special Reference to Tackle Plays” British Journal of Sports Medicine, 2003, 37 416-419 Print
Plasma lactate and K+ concentrations also showed appreciable increases after the match, whereas plasma Na+ concentration showed a gradual decrease. The mean duration of the work and rest periods were 21.5 (2.2) and 24.3 (3.1) seconds respectively. It is concluded that the rugby matches resulted in serious structural damage to the muscles, the extent of which was highly dependent on the number of tackles.

Bianca W M Schalk et al., (2004) conducted a study on the Lower levels of serum albumin and total cholesterol and future decline in functional performance in older persons. The Longitudinal Aging Study Amsterdam Background of concerned study is mentioned that both serum albumin and total cholesterol are potential markers of frailty. A decline in functional status is one of the key components of frailty. The aim of this study was to investigate the association of serum albumin and total cholesterol, separately and combined, with future decline in functional performance. The Longitudinal Aging Study Amsterdam, an ongoing population-based longitudinal study, started in 1992/1993 with a follow-up every 3 years. 1,064 men and women aged 55–85 years with complete data on serum albumin and total cholesterol at baseline, and functional performance at baseline and 3-year follow-up. At baseline, serum albumin and total cholesterol were measured. At baseline and 3 years later, decline in functional status was measured with three performance tests (chair stand, 3-metre walk, putting on and taking off a cardigan). Associations were adjusted for age, lifestyle, and health-related factors. Results albumin concentration was not associated with decline in functional performance in men and women. Women with lower serum total cholesterol concentration (<5.2 mmol/l) were more likely to decline in functional status compared to women with higher serum total cholesterol concentration (reference, OR = 2.50, 95% CI 1.07–5.84). Men with lower serum albumin (<43 g/l) and lower serum total cholesterol concentration were three times more likely to decline in functional performance compared to men with higher levels (OR = 3.00, 95% CI 1.00–8.97). In women, a similar trend was found (OR = 1.73, 95% CI 0.34–8.94), although not statistically significant. Conclusions a combination of low albumin and low cholesterol levels may increase the risk of future functional decline.
Whiting P H, R J Maughan and J D B Miller (1984) conducted a study on the effects of a competitive marathon race on serum biochemical and hematological parameters. Blood samples were obtained shortly before and immediately after the race, urine samples were also obtained before and after the race. Body weight was recorded pre- and post-race. During the race, subjects consumed a total of 1.41 of either water or a dilute glucose-electrolyte solution. The average weight loss of the runners was 2.09±0.77 kg (mean ± SD), corresponding to 2.9±0.8% of body weight. Small but significant increases in both haematocrit and hemoglobin concentration occurred. Plasma volume was calculated to decrease by 4.7%. Serum potassium concentration showed no change, but the response was highly variable, serum sodium concentration increased in line with the decrease in plasma volume. In the group of subjects drinking water during the race, the pre-race plasma glucose concentration was 5.3±1.2 mmol L⁻¹, this was unchanged after the race (5.0±1.2 mmol L⁻¹). A significant increase (P<0.01) in the plasma glucose concentration, from 5.2±0.6 to 6.0±1.5 mmol L⁻¹, occurred in the group of subjects drinking the glucose-electrolyte solution. Apart from this, there were no significant differences between the two groups.

Lon Kilgore J and Glenn W Pendley (2002) conducted a study on the Serum Chemistry and Hematological Adaptations to 6 Weeks of Moderate to Intense Resistance Training. This study examined immune cell and blood chemistry changes occurring in trained weightlifters after 1 week of rest followed by 6 weeks of Olympic-style resistance exercise. Blood was drawn weekly after 1 day of rest at the same time and on the same day of the week for 7 weeks. Lymphocyte numbers increased in weeks 5 through 7. Sodium concentration rose above entry levels in week 2, remained elevated, and peaked in week 5. Direct bilirubin dropped below baseline values in the final week. Chloride and alkaline phosphatase concentrations increased as training progressed. Chloride, potassium, albumin, CO₂, and alkaline phosphatase concentrations peaked in weeks 4.


through 6 Serum creatinine was elevated in weeks 2 through 5. Data indicate that resistance training induces changes in immune cell count and blood chemistry that remain within, or near, normal clinical values. It appears that resistance training does not induce immunosuppression or negatively.

Narayanasamy T et al., (2010) conducted a study on regular exercise training is recognized as a powerful tool to improve work capacity, endothelial function and the cardiovascular risk profile in obesity. To achieve this purpose, the present research was undertaken to investigate that the effect of aerobic training programme performed at different intensities reduces the lipid profiles and enhances the antioxidant status in middle aged obese men. In our study thirty men with coronary heart disease and their age ranges between 35 and 40 years were selected as subjects. They were divided into three groups with 10 members of each. Group I and Group II treated as experimental groups performing aerobic training at low intensity and medium intensity whereas group III remains as control with no practice of aerobic training other than regular activities.

Aerobic training programme was conducted for a period of 3 months (3 days/week) to the experimental groups. Data were collected and biochemical analysis was done. We observed significant alterations on lipid profiles and enhancement in the antioxidant status in aerobic training groups. Studies also proved that better effect was seen in medium intensity of aerobic training groups than others. Results were statistically analyzed using Anova and DMRT and are significant at p<0.05. Hence the study concludes that aerobic training plays a vital role in reducing the risk factors of cardiac disease by retaining the antioxidant status and shows the importance of health benefits of the today's well being.

Dan Streja, and David Mymin (1979) conducted a study on the moderate exercise and high density lipoprotein cholesterol observations during a cardiac rehabilitation program. The effects of a 13-week moderate exercise program on fasting plasma insulin, lipids, and lipoprotein cholesterol concentrations were studied in 32


Dan Streja, and David Mymin, “Moderate Exercise and High-Density Lipoprotein-Cholesterol Observations during a Cardiac Rehabilitation Program.” JAMA The Journal of the American Medical Association. 1979, 242(20) 2190-2192 Print
sedentary, middle-aged men with coronary artery disease. The preponderant components of the exercise program was walking or slow jogging. There was no significant change in the systolic blood pressure and pulse rate product response to a standard exercise load. The high-density lipoprotein-cholesterol (HDL-C) level increased, and the fasting plasma insulin concentration decreased. There were no significant changes in plasma triglycerides or low-density lipoprotein cholesterol levels.

In sedentary subjects with coronary artery disease, a modest increase in activity can result in an increase in the HDL-C level and a decrease in the plasma insulin concentration. These changes occurred in the absence of variations in diet, smoking habits, adiposity, or plasma triglyceride concentrations and did not require a cardiovascular training effect.

Zung Vu Tran and Arthur Weltman (1985) conducted a research on differential effects of exercise on serum lipid and lipoprotein levels seen with changes in body weight. A meta-analysis. Ninety-five studies conducted between September 1955 and October 1983 measuring changes in human serum lipid and lipoprotein levels in response to exercise training were analyzed using meta-analysis. Change in body weight during exercise training may confound observed serum lipid and lipoprotein level changes, thus, data from these studies were partitioned into those where subjects gained body weight, maintained body weight, or lost body weight. Results showed differential changes in cholesterol, triglyceride, low-density lipoprotein-cholesterol (LDL-C), high-density lipoprotein-cholesterol, and cholesterol/high-density lipoprotein-cholesterol levels in the three body-weight categories. Where body weight did not change, cholesterol and LDL-C levels decreased significantly (7.3 mg/dL and 3.3 mg/dL, respectively). Where body weight decreased, cholesterol and LDL-C levels also decreased significantly (13.2 mg/dL and 11.1 mg/dL, respectively). However, with body-weight increase, cholesterol and LDL-C levels increased by 2.9 mg/dL and 3.0 mg/dL, respectively. These results suggest that reductions in cholesterol and LDL-C levels were greatest when exercise training was combined with body-weight losses.

Zung Vu Tran and Arthur Weltman “Differential Effects of Exercise on Serum Lipid and Lipoprotein Levels Seen with Changes in Body Weight: A Meta-analysis” 1985, 254(7) 919-924 Print
Giuseppe Lippi, Paola Brancaccio and Nicola Maffulli (2010) conducted a study on Biochemical markers of muscular damage and the study says that muscle tissue may be damaged following intense prolonged training as a consequence of both metabolic and mechanical factors. Serum levels of skeletal muscle enzymes or proteins are markers of the functional status of muscle tissue, and vary widely in both pathological and physiological conditions. Creatine kinase, lactate dehydrogenase, aldolase, myoglobin, troponin, aspartate aminotransferase, and carbonic anhydrase CAIII are the most useful serum markers of muscle injury, but apoptosis in muscle tissues subsequent to strenuous exercise may be also triggered by increased oxidative stress. Therefore, total antioxidant status can be used to evaluate the level of stress in muscle by other markers, such as thio-barbituric acid-reactive substances, malondialdehyde, sulphydryl groups, reduced glutathione, oxidized glutathione, superoxide dismutase, catalase and others. As the various markers provide a composite picture of muscle status, we recommend using more than one to provide a better estimation of muscle stress.

De Paz J A et al. (1995) conducted a study on effects of long-distance running on serum bilirubin. This study was undertaken to determine the effects of long-distance running on serum bilirubin fractions. Thirteen male ultramarathon runners participating in a 100-km race volunteered for the study. Venous blood samples were obtained shortly before and immediately after the race. Decreased serum haptoglobin levels (-66%) indicated the presence of hemolysis. After accounting for plasma-volume loss, significant post-race increases were found for creatine kinase (+20-fold), creatine kinase-MB (+252%), alanine aminotransferase (+42%), aspartate aminotransferase (+193%), gamma-glutamyl transpeptidase (+56%), and glutamate dehydrogenase (+58%) serum activities, suggesting that running causes alterations of both muscle and liver tissues. Serum concentration of total bilirubin was significantly elevated (+106%) following the race, with changes corresponding to both unconjugated (+96%) and conjugated esters (+283%) of the pigment and significant increases in the ratio of esterified to total bilirubin.
bilirubin. Our data show that long-distance running causes increases in the different serum bilirubin fractions which can be accounted for both hemolysis and hepatic disturbances.

McLellan, C P, Lovell, D I, and Gass, G C (2010) conducted a study on Creatine kinase and endocrine responses of elite players pre, during, and post rugby league match play. The purpose of the present study was to (a) examine player-movement patterns to determine total distance covered during competitive Rugby League match play using global positioning systems (GPSs) and (b) examine pre, during, and postmatch creatine kinase (CK) and endocrine responses to competitive Rugby League match play. Seventeen elite rugby league players were monitored for a single game. Player movement patterns were recorded using portable GPS units (SPI-Pro, GPSports, Canberra, Australia). Saliva and blood samples were collected 24 hours prematch, 30 minutes prematch, 30 minutes postmatch, and then at 24-hour intervals for a period of 5 days postmatch to determine plasma CK and salivary testosterone, cortisol, and testosterone cortisol ratio (T/C). The change in the dependent variables at each sample collection time was compared to 24-hour prematch measures. Backs and forwards traveled distances 5,747 ± 1,095 and 4,774 ± 1,186 m, respectively, throughout the match. Cortisol and CK increased significantly (p < 0.05) from 30 minutes prematch to 30 minutes postmatch. Creatine kinase increased significantly (p < 0.05) postmatch, with peak CK concentration measured 24 hours postmatch (889 ± 25 27 U L⁻¹). Cortisol displayed a clear pattern of response with significant (p < 0.05) elevations up to 24 hours postmatch, compared with 24 hours prematch. The GPS was able to successfully provide data on player-movement patterns during competitive rugby league match play. The CK and endocrine profile identified acute muscle damage and a catabolic state associated with Rugby League match play. A return to normal T/C within 48 hours postmatch indicates that a minimum period of 48 hours is required for endocrine homeostasis post competition. Creatine kinase remained elevated despite 120 hours of recovery postmatch identifying...
that a prolonged period of at least 5 days modified activity is required to achieve full recovery after muscle damage during competitive Rugby League match play.

Peter Daniel Peeling (2009) conducted a study on the exercise-induced hemolysis, inflammation and hepcidin activity in endurance trained runners. Iron is a trace mineral used by the body in many physiological processes that are essential to athletic performance. Commonly, the body's iron stores are compromised by exercise via several well-established mechanisms. One such mechanism is the destruction of red blood cells (hemolysis), in response to the mechanical stress and circulatory strain of exercise. Although it appears that a force-dependent relationship between the heel-strike of the running gait and ground contact exists, the effects of the intensity trained at and the ground surface type trained upon have not been documented. Similarly, the effects of a cumulative training stress (i.e., multiple daily sessions) has not been examined. In addition to hemolysis, exercise also invokes an inflammatory response that results in an up-regulation of the cytokine interleukin-6 (IL-6). This cytokine is the primary mediator of hepcidin expression, a liver-produced hormone that regulates iron metabolism in the gut and in macrophages. The influence of exercise on hepcidin expression is relatively unknown, and as such it is possible that this hormone may be a mitigating factor implicated in athletic-induced iron deficiency. Therefore, the purpose of this thesis was to investigate the effect of different training frequencies, intensities, and ground surfaces on the hemolytic response. In addition, the impact of exercise-induced inflammation on hepcidin expression in the 24 h post-exercise was investigated, with the aim of determining whether this hormone may be a potential new mechanism associated with athletic-induced iron deficiency. Finally, an interaction between hemolysis and hepcidin activity was examined to investigate their potential combined effect on iron status in the 24 h post-exercise. Venous blood and urine samples were collected pre- and immediately post-exercise, and at 3 and 24 h of recovery. Samples were analysed for circulating levels of IL-6, free Hb, Hp, serum iron, ferritin, and urinary hepcidin activity. At the conclusion of both the T1 and T2 interval runs, the free Hb and serum Hp were significantly increased (p<0.05) from pre-exercise levels. Furthermore, a cumulative effect of two...
running sessions was shown in the T2 trial, via a further significant fall in serum Hp. The IL-6 and hepcidin activity were significantly increased after each running session (p<0.05) with no cumulative effect seen. Serum iron and ferritin were significantly increased post-exercise after each interval run (p<0.05), but were not influenced by the addition of a prior LSD run 12 h earlier. As a result, this investigation showed a cumulative effect of consecutive training sessions on RBC destruction in male athletes. Furthermore, post-exercise increases to serum iron and hepcidin, and their interaction was suggested to have potential implications for an athlete's iron status. Overall, the findings of this thesis show that hemolysis is evident at the conclusion of endurance running, and is influenced by training intensity and frequency. The results enabled a time-lime for hepcidin expression post-exercise to be established, and the implications of increases to the activity of this hormone, in association with the hemolytic changes seen with endurance exercise are discussed.

Zavorsky G S, et al., (2002) conducted a study on circulating white blood cells affect red cell pulmonary transit times in endurance athletes during intense exercise. The aim of this study was to determine the relationship between the right-to-left ventricular red cell pulmonary transit times (PTT) during intense exercise and circulating white blood cell (WBC) counts in highly trained endurance athletes. We postulated that high levels of WBCs preexercise would slow PTT. Eleven endurance-trained athletes (VO2max = 69.6 +/- 7.7 mL kg^-1 min^-1, weight = 75.0 +/- 6.2 kg, height = 181.0 +/- 7.1 cm) performed 6.5 min constant-load, near-maximal cycling exercise (approximately 92% VO2max) on two different days. Preexercise WBC counts were measured in arterial blood drawn from the radial artery 30 min before exercise. PTT was measured during the 3rd min of exercise by first-pass radionuclide cardiography using centroid and deconvolution analysis, whereas cardiac output (Q) was measured during the last 2.5 min of exercise via a count-based ratio method from the MUGA technique. Combined mean PTT from both deconvolution and centroid analysis at minute three of exercise was 2.45 +/- 0.21 s, whereas the preexercise WBC count was 5.3 +/- 1.6 x 10^9 L^-1.

Cardiopulmonary blood volume at minute three of exercise was 1.22 +/- 0.13 L, VO2 was 4.58 +/- 0.44 L min^-1, and Q was 30.2 +/- 4.2 L min^-1. We found that PTT was negatively correlated with circulating WBC (r = -0.61, adjusted r^2 = 0.30, P = 0.04, N = 11) but not with the dispersion (spread) of transit times around the mean (r = 0.19, P = 0.57). The study suggests that athletes with higher circulating numbers of WBCs preexercise have faster (shorter) red cell transit times through the lung during intense exercise.

Timothy D. Noakes (1987), Effect of Exercise on Serum Enzyme Activities in Humans and his summary says that increased serum enzyme activity after exercise was first reported in 1958, subsequent studies have established that many factors determine the degree to which the serum activities of a variety of enzymes increase during and after exercise. The serum activities of those enzymes found especially in muscle, particularly creatine kinase, increase in proportion to the intensity and duration of the preceding exercise, peaking 24 hours after exercise, the effect of duration is dominant, so that the highest postexercise serum enzyme activities are found after very prolonged competitive exercise such as ultradistance marathon running or triathlon events. Weight-bearing exercises which include eccentric muscular contractions such as bench stepping and downhill running induce the greatest increases in serum enzyme activities, serum enzyme activities increase very little even after prolonged participation in those non-weight-bearing activities such as swimming and cycling which do not include eccentric muscular contractions. Prolonged (>2 hours) daily training or competition in weight-bearing activities produces chronically elevated serum enzyme activities. Serum enzyme activities increase more with exercise in males, Blacks and the untrained than they do in females, Whites and the trained, respectively, age does not appear to influence the degree to which serum enzyme activities increase with exercise. There is a remarkable individual variability in the degree to which serum enzyme activities increase with exercise, a 50-fold difference in post-race serum creatine kinase activities has been found in healthy and equally trained athletes completing the same 90km ultra-marathon footrace. The biochemical explanation for this degree of individual variability is not currently

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understood, possibly persons who show abnormally large increases in serum enzyme activities with exercise may have as yet unrecognised subclinical myopathies. No circadian rhythms have been identified for serum enzyme activities; activities rise during the day because of increased physical activity. The rise in serum enzyme activities is greater after exercise at altitude or in the heat than after equivalent exercise at sea level or in the cold.