KESAN *SYMPATETHIC OVERTRAINING* TERHADAP TEMPOH PEMULIHAN KADAR NADI DAN NILAI AMBANG ASID LAKTIK

AZRISAN BIN AHSAN

FAKULTI PSIKOLOGI DAN PENDIDIKAN
UNIVERSITI MALAYSIA SABAH
2019

KESAN *SYMPATETHIC OVERTRAINING* TERHADAP TEMPOH PEMULIHAN KADAR NADI DAN NILAI AMBANG ASID LAKTIK

AZRISAN BIN AHSAN

TESIS INI DISERAHKAN UNTUK MEMENUHI KEPERLUAN PENGIJAZAHAN IJAZAH SARJANA SAINS

FAKULTI PSIKOLOGI DAN PENDIDIKAN
UNIVERSITI MALAYSIA SABAH
2019

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS TESIS

JUDUL: **KESAN *SYMPATHETIC OVERTRAINING* TERHADAP TEMPOH PEMULIHAN KADAR NADI DAN NILAI AMBANG ASID LAKTIK**

IJAZAH: **SARJANA SAINS (SAINS SUKAN)**

Saya **AZRISAN BIN AHSAN**, Sesi **2013-2019**, mengaku membenarkan tesis Sarjana ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:-

1. Tesis ini adalah hak milik Universiti Malaysia Sabah
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (/):

[ ]	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA 1972)
[ ]	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
[/]	TIDAK TERHAD	

Disahkan Oleh,

NORAZLYNNE MOHD. JOHAN @ JACKLYNE
PUSTAKAWAN
UNIVERSITI MALAYSIA SABAH

(Tandatangan Pustakawan)

AZRISAN BIN AHSAN
MT1221006T

Tarikh : 26 September 2019

(Prof. Madya Dr. Dayang Maryama bt. Awang Daud)
Penyelia

PENGAKUAN

Saya dengan ini mengaku bahawa karya ini adalah hasil kerja saya sendiri kecuali nukilan, ringkasan, dan rujukan yang tiap-tiap satunya telah saya jelaskan sumbernya.

29 Januari 2019

Azrisan bin Ahsan

MT1221006T

PENGESAHAN

NAMA	:	**AZRISAN BIN AHSAN**
NO. MATRIK	:	**MT1221006T**
TAJUK	:	**KESAN *SYMPATHETIC OVERTRAINING* TERHADAP TEMPOH PEMULIHAN KADAR NADI DAN NILAI AMBANG ASID LAKTIK**
IJAZAH	:	**SARJANA SAINS (SAINS SUKAN)**
TARIKH VIVA	:	**20 OGOS 2019**

DISAHKAN OLEH;

PENYELIA Tandatangan

Prof. Madya Dr. Dayang Maryama bt. Awang Daud

PENGHARGAAN

Syukur ke hadrat Allah SWT di atas keizinan dan petunjuk-Nya yang memberikan keupayaan bagi saya untuk menyiapkan tesis ini bagi memenuhi sebahagian syarat Ijazah Sarjana Sains Sukan.

Di bawah seliaan penyelia saya, Prof. Madya Dr. Dayang Maryama bt. Awang Daud, saya menerima segala macam tunjuk ajar, dorongan, kata-kata semangat, dan sokongan. Saya ingin mengambil kesempatan ini dengan serendah-rendah hati saya untuk mengucapkan jutaan terima kasih kepada beliau di atas kesabaran dan keihlasan beliau dalam membimbing saya menyiapkan tesis ini.

Tidak lupa kepada kedua orang tua dan ahli keluarga saya yang menjadi tulang belakang sepanjang tempoh pengajian saya; yang tidak henti-henti mendoakan kejayaan saya dan sentiasa memberikan sokongan kepada saya dalam bentuk sokongan moral mahu pun dari segi material sehingga saya berjaya menyelesaikan kajian saya.

Sejuta penghargaan juga buat rakan-rakan seperjuangan yang tidak pernah berhenti menyokong saya dan berkongsi ilmu dan memudahkan lagi perjalanan kajian saya. Tidak lupa kepada semua individu yang terlibat sama ada secara langsung mahu pun tidak langsung dalam menjayakan kajian ini. Semoga semua usaha kita dalam menyiapkan tesis ini akan mendatangkan hasil dan menjadi pendorong kepada individu-individu lain ke arah kejayaan yang lebih baik pada masa hadapan.

Sekian, terima kasih.

AZRISAN AHSAN
29 Januari 2019

ABSTRAK

Ketidakseimbangan di antara intensiti latihan, beban kerja, dan jumlah masa rehat yang mencukupi mungkin mampu menyumbang kepada sindrom *overtraining. Overtraining* tahap dua; juga dikenali sebagai *sympathetic overtraining* lebih kerap berlaku dalam kalangan atlet yang memfokuskan kepada latihan bercirikan pecutan dan kuasa serta gaya hidup yang menyumbang kepada tekanan serta atlet yang terlalu kerap berlatih. Tujuan kajian ini adalah untuk mengkaji kesan *sympathetic overtraining* terhadap tempoh pemulihan kadar nadi individu; yang merujuk kepada jumlah masa yang diperlukan oleh kadar nadi selepas senaman untuk kembali kepada kadar nadi sebelum senaman; serta nilai ambang asid laktik. Seramai lima orang atlet rekreasi telah menjalani latihan larian di atas *treadmill* secara intensif dua sesi sehari selama 14 hari berturut-turut. Ujian prestasi yang melibatkan ujian larian di atas *treadmill,* ujian nilai ambang asid laktik, dan ujian tempoh pemulihan kadar nadi dilakukan sebanyak tiga kali sepanjang kajian. RPM ANOVA menunjukkan *sympathetic overtraining* memberi kesan ke atas tempoh pemulihan kadar nadi ($F(2) = 4.633$, $p = 0.046$). Nilai ambang asid laktik juga menunjukkan perubahan yang signifikan berikutan *sympathetic overtraining* ($F(2) = 24.609$, $p = 0.000$). Ujian t-berpasangan pula menunjukkan tiada perbezaan signifikan bagi ujian pra dan pasca kajian bagi tempoh pemulihan kadar nadi ($t = 1.371$, $p = 0.242$) manakala ujian nilai ambang asid laktik menunjukkan perubahan yang signifikan ($t = -5.365$, $p = 0.006$). Dapatan kajian ini membuktikan bahawa *sympathetic overtraining* menyebabkan tempoh pemulihan kadar nadi semakin perlahan dan nilai ambang asid laktik semakin lambat di capai. Kajian yang lebih mendalam dengan saiz sampel yang lebih besar perlu dijalankan untuk mengesahkan dapatan kajian ini boleh digunakan untuk mengesahkan penggunaan tempoh pemulihan kadar nadi dan nilai ambang asid laktik dalam pengesanan awal *sympathetic overtraining*.

ABSTRACT

SYMPHATETIC OVERTRAINING EFFECT TOWARDS TIME FOR HEART TO RECOVER AND LACTATE THRESHOLD

The imbalance between training intensity, workload, and recovery time might lead to overtraining syndrome. Second stage of overtraining; also known as sympathetic overtraining often occurs towards athletes who are focusing on sprinting and power training, living a lifestyle that contributes to excessive stress, and who train too often. The aim of this research is to study the effect of sympathetic overtraining towards the time for heart to recover; in which refers to the amount of time for the post-exercise heart rate to return to the pre-exercise heart rate; as well as the lactate threshold. Five recreational athletes went through 14 days of two sessions per day of treadmill running training. The subjects also went through three sessions of performance testing which include running on treadmill, lactate threshold test, and time for heart to recover test. RPM Anova showed a significant difference for time for heart to recover ($F(2) = 4.633$, $p = 0.046$). Lactate threshold also showed significant difference following sympathetic overtraining ($F(2) = 24.609$, $p = 0.000$). Paired t-test showed there is no significant difference for pre- and post-test ($t = 1.371$, $p = 0.242$) while lactate threshold otherwise ($t = -5.365$, $p = 0.006$). The finding in this study proved that sympathetic overtraining caused significant increase for time for heart rate to recover and lactate threshold is achieved much later. A more thorough study with bigger sample size need to be done to further prove the finding in this study that time for heart to recover and lactate threshold can be used for early detection sympathetic overtraining.

ISI KANDUNGAN

BAB 3: METODOLOGI KAJIAN

BAB 4: DAPATAN KAJIAN

SENARAI JADUAL

SENARAI RAJAH

SENARAI SINGKATAN

ANOVA	*Analysis of Varians*
HRR	*Heart Rate Recovery*
LDH	*Lactate Dehydrogenase*
LT	*Lactate Threshold*
MLSS	*Maximal Lactate Steady State*
PSOT	*Parasympathetic Overtraining*
SOT	*Sympathetic Overtraining*
OBLA	*Onset Blood Lactate Accumulation*

BAB 1

PENGENALAN

1.1 Pengenalan

Salah satu cabaran terbesar dalam program latihan atlet adalah untuk mengoptimumkan program tersebut untuk mendapatkan hasil yang terbaik dari segi prestasi. Hal ini adalah sesuatu yang amat rumit kerana program latihan yang tidak mapan boleh menyebabkan dua perkara – sama ada atlet tidak mencapai tahap prestasi mengikut potensi sebenarnya atau pun atlet tersebut akan mengalami kesan adaptasi negatif latihan yang boleh menyebabkan penurunan prestasi yang teruk (Meeusen et al., 2013). Cabaran terbesar untuk atlet dan juga jurulatih adalah dalam menentukan gabungan isi padu latihan dan jenis latihan yang sempurna yang boleh mengoptimumkan prestasi atlet dan mengelakkan berlakunya adaptasi negatif.

Walau bagaimanapun, disebabkan wujudnya prinsip perbezaan individu dalam latihan, tugas ini menjadi semakin rumit kerana jurulatih harus merekabentuk program latihan yang bersesuaian dengan individu; program latihan yang boleh mengoptimumkan prestasi sesetengah atlet mungkin boleh menyebabkan berlakunya kekurangan latihan atau pun kelebihan latihan dalam sesetengah atlet yang lain (Wilmore, Costill, & Kenney, 2008).

Selain daripada itu, tekanan dalaman dan luaran sebagai seorang atlet, serta aktiviti harian seperti jumlah kuliah yang banyak, masalah peribadi, dan tekanan dari rakan sebaya juga turut perlu diambil kira kerana hal ini mampu memberikan respon negatif kepada prestasi semasa atlet (Budgett, 1998; Carfagno & Hendrix, 2014; M. Kellman, 2010). Prestasi atlet boleh menurun selama beberapa minggu atau bulan

walaupun rehat diberikan atau isipadu latihan dikurangkan disebabkan hal-hal tersebut. Situasi ini dikenali sebagai *overtraining* dan boleh menyebabkan penurunan prestasi yang mengancam kerjaya atlet tersebut.

1.2 Latar Belakang Kajian

Kerap kali apabila Sukan Olimpik menjelma, kita sering disajikan dengan pelbagai berita mengenai atlet-atlet yang menarik diri atau mengalami kecederaan berikutan tekanan fizikal dan psikologikal yang dialami oleh mereka yang dikaitkan dengan *burnout* mahu pun *overtraining.* Selain itu, kita juga sering dihebahkan dengan berita-berita mengenai atlet-atlet berprofil tinggi yang mengalami *overtraining* berikutan latihan yang melampau seperti kes yang dialami oleh Whitney Myers; seorang bintang sukan renang muda kelahiran Amerika Syarikat yang mengalami *overtraining* yang menghancurkan harapannya untuk bertanding di Sukan Olimpik Beijing 2008. Begitu juga dengan Anthony Ervin yang turut mengalami *overtraining* tetapi masih mampu kembali beraksi di Sukan Olimpik Rio 2016.

Kajian yang dijalankan oleh Koutedakis & Sharp (1998) mendapati bahawa seramai 15% daripada 600 orang atlet elit United Kingdom mengalami *overtraining.* Kajian oleh Matos, Winsley, & Williams (2011) yang dijalankan dalam kalangan atlet elit dewasa mendapati bahawa sekurang-kurangnya 30% atlet mengalami *overtraining* sekurang-kurangnya sekali dalam sepanjang karier mereka. Risiko mengalami *overtraining* semakin tinggi dalam sukan individu, wanita, dan atlet elit. Satu persidangan khas mengenai fenomena ini; *International Conference of Overtraining in Sport* telah dilangsungkan di Universiti Memphis menjelang Sukan Olimpik Atlanta 1996 dalam usaha untuk menarik perhatian para pengkaji sukan, ahli fizikal, dan jurulatih dalam usaha untuk membincangkan isu ini.

Banyak kajian telah dijalankan semenjak tiga dekad yang lalu dalam usaha untuk mengenalpasti punca, simptom, dan hipotesis serta petanda yang boleh mengenalpasti fenomena ini. Walau bagaimanapun, tugas untuk mendiagnos ini

adalah sangat sukar berikutan simptom *overtraining* yang menyerupai adaptasi terhadap latihan yang normal (Kreher & Schwartz, 2012; Polito et al., 2017). Beberapa simptom telah diguna pakai dalam sorotan literatur kajian-kajian sebelum ini. Antara simptom-simptom tersebut adalah simptom fisiologikal seperti penurunan prestasi fizikal, kekuatan otot, koordinasi, dan perubahan keluk asid laktik (Blank et al., 2012; Bosquet, Léger, & Legros, 2001; Meeusen, Watson, Hasegawa, Roelands, & Piacentini, 2007; Wyatt, Donaldson, & Brown, 2013). Simptom-simptom biokimia turut dilaporkan seperti penurunan kandungan oksigen otot, kandungan mineral tulang, testosteron bebas dan nisbah testonsteron/kortisol melebihi 30%, dan penurunan kortisol dan urea (Blank et al., 2012; Hug, Mullis, Vogt, Ventura, & Hoppeler, 2003; M Lehmann, U Gastmann, KG Petersen, N Bcahl, A Seidel, AN Khalaf, S Ficsher, 1992; Wyatt et al., 2013).

Simptom-simptom psikologikal seperti kemurungan, tekanan emosi, dan kebimbangan terhadap pertandingan yang melampau (Dos Santos Cunha, Ribeiro, & De Oliveira, 2006; Meeusen et al., 2013; Purvis, Gonsalves, & Deuster, 2010) serta simptom-simptom imunologikal seperti jangkitan dan penyakit yang kerap dan penurunan aktiviti neutrofil dan makfrofaj (Blank et al., 2012; Gleeson, 2002; Kasikcioglu et al., 2008).

Terdapat banyak istilah dan definisi yang digunakan untuk menjelaskan mengenai sindrom ini dan hal ini telah menyebabkan wujudnya kekeliruan. *Overtraining* boleh ditafsirkan sebagai keadaan penat atau lesu yang berpanjangan dalam diri atlet yang mana ia berpunca daripada latihan yang berlebihan (Armstrong & Van Heest, 2002; Meeusen et al., 2013). Situasi ini selalunya dapat digambarkan melalui penurunan atau pengekalan tahap prestasi walaupun latihan diteruskan (Jeukendrup & Hesselink, 1994; Carfagno & Hendrix, 2014). *Overtraining* juga dianggap sebagai respon am stres terhadap latihan yang berisipadu dan berintensiti tinggi dengan jumlah rehat dan tempoh pemulihan yang tidak mencukupi di antara sesi latihan (Budgett, 1990; Hooper & Mackinnon, 1995). *Overtraining* boleh ditakrifkan sebagai ketidakseimbangan dalam persamaan berikut: program latihan = sesi latihan + masa pemulihan (Halson & Jeukendrup, 2004).

Maffetone (2015) mengkelaskan overtraining kepada tiga bahagian iaitu functional overtraining, sympathetic overtraining, dan parasympathetic overtraining. Functional overtraining merujuk kepada fenomena overreaching; yang mana peningkatan intensiti senaman dilakukan dengan sengaja untuk merangsang supercompensation (Birrer, Lienhard, Williams, Röthlin, & Morgan, 2013; Meur, Y.L., Buccheit, M., Aubry, A., & Coutts, A.J., 2015). Sympathetic overtraining pula merujuk kepada pengaktifan sistem saraf simpatetik secara berlebihan berikutan peningkatan intensiti dan/atau isipadu senaman secara berlebihan yang ditandai dengan simptom peningkatan kadar nadi rehat dan kadar nadi senam (Maffetone, 2015). Parasympathetic overtraining pula merujuk kepada overtraining yang kronik, yang mana sistem saraf parasimpatetik mengalami gangguan dan menyebabkan simptom-simptom seperti penurunan kadar nadi senaman dan penurunan hormon kortisol serta gangguan mood yang teruk (Hedelin, R., Wiklund, U., Bjerle, P., & Henriksson-Larsén, K., 2000; Maffetone, 2015).

Sympathetic overtraining kerap berlaku dalam kalangan individu yang memfokuskan kepada latihan berasaskan pecutan dan kuasa, individu yang terlaku kerap berlatih, individu dengan keadaan sekeliling yang boleh menyumbang kepada tekanan hidup, dan selalunya individu yang mempunyai gabungan kesemua faktor-faktor ini (Maffetone, 2015). Salah satu petanda yang paling dominan *sympathetic overtraining* ini adalah peningkatan kadar nadi rehat dan peningkatan penghasilan hormon kortisol (Maffetone, 2015; Hug et al., 2003). Selain itu, peningkatan kadar nadi senam pada intensiti senaman yang sama turut berlaku (Maffetone, 2015).

Peningkatan kadar nadi rehat dan senam yang berlaku ketika *sympathetic overtraining* ini adalah berikutan daripada pengaktifan sistem saraf simpatetik yang berlebihan (Kasikcioglu, Oflaz, Oncul, Kayserilioglu, Umman, & Nisanci, 2008; Peçanha, Silva-Junior, & Forjaz, 2014). Intensiti senaman yang tinggi juga mempengaruhi sistem saraf simpatetik (Kannankeril & Goldberger, 2002). Berikutan intensiti dan/atau isipadu senaman yang dijalankan yang terlalu tinggi maka berlaku peningkatan jumlah *catecholamines* dalam darah yang mana ia ini mampu mempengaruhi kadar tekanan nadi semasa bersenam melalui rembesan hormon *epinephrinee* (Petibois, Cazorla, Poortmans, & Deleris, 2003).

Pengaktifan semula sistem saraf parasimpatetik selepas bersenam adalah lebih cepat berbanding dengan penyahaktifan sistem saraf simpatetik tetapi sistem saraf simpatetik masih mempengaruhi sistem kardiak (Kannankeril, Le, Kadish, & Goldberger, 2004). Pengaktifan sistem saraf simpatetik yang berlebihan akan menyebabkan ia mempunyai pengaruh yang tinggi terhadap sistem kardiak dan boleh memperlahankan kadar nadi semasa pemulihan.

Walau bagaimanapun, hal ini tidak mengesahkan bahawa kadar nadi pemulihan seminit selepas senaman dihentikan adalah petanda yang sahih digunakan untuk mengesan *sympathetic overtraining* berikutan kenyataan bahawa sistem saraf parasimpatetik memainkan perangan yang sangat penting dalam memulihkan kadar denyutan jantung sejurus selepas senaman dihentikan (Kasikcioglu et al., 2008). Imai, Sato, Hori, Kusuoka, Ozaki, Yokoyama, Takeda, Inoue, & Kamada (1994) dalam kajian mereka mendapati bahawa sistem saraf parasimpatetik memainkan peranan penting dalam pemulihan kadar nadi pada 30 saat yang pertama. Hal ini menyebabkan wujud keraguan bahawa pengaktifan sistem saraf parasimpatetik selepas senaman tidak memberikan gambaran sepenuhnya sistem saraf simpatetik yang terlebih aktif. Jumlah tempoh masa yang diambil untuk kadar nadi selepas senaman kembali kepada kadar nadi sebelum senaman mungkin boleh memberikan gambaran yang lebih luas mengenai hal ini.

Selain daripada kadar nadi pemulihan, pergerakan keluk asid laktik juga merupakan salah satu petanda yang dikaji dalam memahami simptom *overtraining.* Jeukendrup & Hesselink (1994) mendapati bahawa berlakunya pemindahan keluk graf asid laktik ke kanan yang menandakan nilai kepekatan asid laktik yang lebih rendah pada tahap intensiti yang sama selepas dua minggu latihan intensif diberikan. Dapatan sama diperoleh oleh Bosquet, Leger, & Legros (2001) dalam kalangan subjek yang mengalami *overtraining* selepas empat minggu latihan intensif. Kajian yang dijalankan oleh Snyder, Kuipers, Cheng, Servais, & Fransen (1995) pula mendapati bahawa subjek yang menepati kriteria *overtraining* masih mempunyai nilai glikogen semasa rehat yang normal. Dapatan-dapatan ini mewujudkan kemusykilan sama ada pemindahan keluk tersebut berlaku disebabkan pembersihan laktat yang semakin baik

dalam kalangan subjek atau pun mula berlakunya pengosongan/pengurangan glikogen berikutan simptom *overtraining.*

Kajian-kajian terdahulu telah membuktikan wujudnya respon kadar nadi pemulihan dan kepekatan asid laktik dalam membuktikan simptom *overtraining* yang berlaku. Namun begitu, wujud percanggahan pendapat yang membuka ruang untuk perdebatan dan kajian-kajian yang berikutnya. Memandangkan *overtraining* berlaku pada beberapa peringkat (Maffetone, 2015), adalah penting untuk mengkaji fasa *overtraining* yang lain dalam usaha untuk mendapatkan gambaran dan panduan menyeluruh mengenai fenomena ini

Tempoh pemulihan kadar nadi dan nilai ambang asid laktik yang telah dikaji secara meluas dalam kajian mengenai *overtraining* merupakan pemboleh ubah yang dianggap relevan untuk dikaji dalam kajian *sympathetic overtraining* kerana kedua – dua aspek ini amat berkait rapat dengan acara – acara sukan yang berkaitan dengan pecutan dan kuasa (dua faktor yang terlibat secara langsung dengan *sympatheic overtraining* (Maffetone, 2015).

1.3 Pernyataan Masalah

Penggunaan kadar nadi pemulihan dan nilai kepekatan asid laktik telah menjadi salah satu idea yang sering digunakan dalam mengesan fenomena *overtraining* (Bosquet et al., 2001; Gleeson, 2002; Jeukendrup & Hesselink, 1994; Lamberts, Swart, Capostagno, Noakes, & Lambert, 2010; Wyatt et al., 2013). Namun begitu, kurang sorotan kajian yang spesifik mengenai keberkesanan kedua – dua petanda ini dalam mengesan fenomena *sympathetic overtraining. Sympathetic overtraining* merupakan *overtraining* yang berlaku dalam jangka pendek yang boleh mempengaruhi tahap prestasi individu (Maffetone, 2015).

Kajian – kajian yang dijalankan sebelum ini memfokuskan kepada fenomena *overtraining* kronik, iaitu *parasympathetic overtraining.* Disebabkan wujudnya perbezaan jenis *overtraining* (Maffetone, 2015), adalah penting untuk mengkaji aspek *overtraining* yang lain seperti *sympathetic overtraining. Sympathetic overtraining* boleh

berlaku pada jangka masa yang lebih singkat berbanding *parasympathetic overtraining* dan peluang untuk memulihkan atlet yang mengalaminya adalah lebih cerah kerana pengesanan yang lebih awal boleh dilakukan. Dengan itu, kajian ini akan mengkaji kesan *sympathetic overtraining* terhadap tempoh pemulihan kadar nadi dan nilai ambang asid laktik.

1.4 Objektif Kajian

Objektif utama kajian ini adalah untuk mengkaji kesan *sympathetic overtraining* terhadap petanda-petanda fisiologikal tertentu. Pengkaji percaya bahawa dapatan daripada kajian ini akan membantu memberikan sudut pandang dan pengetahuan tambahan terhadap petanda-petanda *sympathetic overtraining.* Untuk mencapai objektif kajian ini, satu kajian quasi-eksperimental telah dijalankan yang melibatkan latihan program intensif yang merangsang *sympathetic overtraining* dalam kalangan subjek. Berikut merupakan objektif spesifik kajian ini:

1.4.1 Mengkaji kesan *sympathetic overtraining* terhadap tempoh pemulihan kadar nadi.

1.4.2 Mengkaji kesan *sympathetic overtraining* terhadap nilai ambang asid laktik.

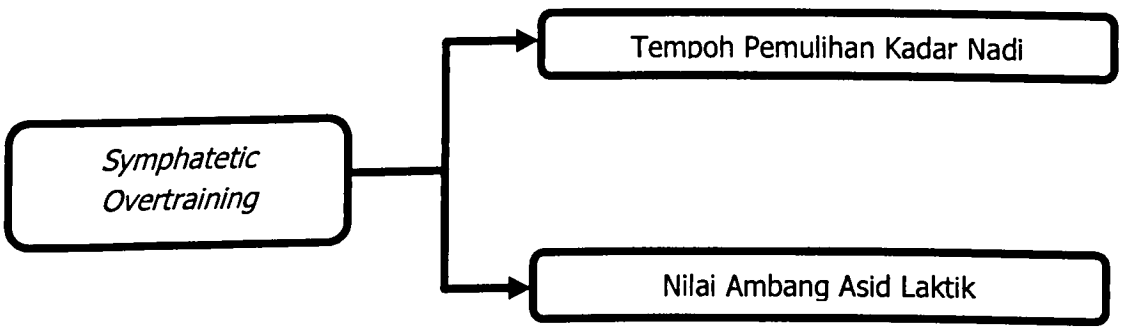
1.5 Hipotesis Kajian

Pengkaji telah merekabentuk dua hipotesis yang digunakan untuk menjawab persoalan kajian. Kesemua data yang diperoleh dalam kajian ini di analisis dan dikaji untuk membuktikan hipotesis-hipotesis berikut:

H_1 = *Sympathetic overtraining* menyebabkan tempoh pemulihan kadar nadi semakin perlahan.

H_2 = *Sympathetic overtraining* menyebabkan nilai ambang asid laktik semakin lambat untuk dicapai.

1.6 Kerangka Konseptual



Rajah 1.0: Kerangka Konseptual

Berdasarkan rajah di atas, kerangka konseptual kajian ini jelas menunjukkan bahawa kajian ini memfokuskan kepada kesan *sympathetic overtraining* terhadap dua pemboleh ubah yang dikaji iaitu tempoh pemulihan kadar nadi dan nilai ambang asid laktik. Dalam sesuatu kajian, terdapat dua jenis pemboleh ubah iaitu pemboleh ubah bebas dan pemboleh ubah terikat (Syed Arabi Idid, 2002). Pemboleh ubah bebas wujud terlebih dahulu sebelum berlakunya tindak balas atau fenomena. Oleh itu, pemboleh ubah bebas dianggap akan mempengaruhi tindak balas atau fenomena yang dikenali sebagai pemboleh ubah terikat (Gratton dan Jones, 2004). Dalam kajian ini, pemboleh ubah bebas *sympathetic overtraining* yang dirangsang melalui program latihan intensif yang telah direka bentuk manakala pemboleh ubah terikat pula adalah respon fisiologi terhadap pemboleh ubah bebas tersebut iaitu tempoh pemulihan kadar nadi dan nilai ambang asid laktik subjek.

Kesemua subjek menjalani program latihan intensif selama 14 hari berturut-turut untuk merangsang *sympathetic overtraining.* Kemudian, kesan daripada

sympathetic overtraining terhadap tempoh pemulihan kadar nadi dan nilai ambang asid laktik ini diuji melalui siri ujian prestasi yang dijalankan.

1.7 Definisi Operasional

Berikut adalah definisi operasional bagi frasa – frasa yang digunakan dalam kajian ini:

1.7.1 *Overtraining*

Overtraining boleh ditafsirkan sebagai keadaan penat atau lesu yang berpanjangan dalam diri atlet yang mana ia berpunca daripada latihan yang berlebihan (Armstrong & Van Heest, 2002; Meeusen et al., 2013). Situasi ini selalunya dapat digambarkan melalui penurunan atau pengekalan tahap prestasi walaupun latihan diteruskan (Jeukendrup & Hesselink, 1994; Carfagno & Hendrix, 2014). *Overtraining* juga dianggap sebagai respon am stres terhadap latihan yang berisipadu dan berintensiti tinggi dengan jumlah rehat dan tempoh pemulihan yang tidak mencukupi di antara sesi latihan (Budgett, 1990; Hooper & Mackinnon, 1995). *Overtraining* boleh ditakrifkan sebagai ketidakseimbangan dalam persamaan berikut: program latihan = sesi latihan + masa pemulihan (Halson & Jeukendrup, 2004).

1.7.2 *Sympathetic overtraining*

Overtraining tahap dua yang mana sistem saraf simpatetik menjadi terlebih aktif (Maffetone, 2015). Salah satu petanda paling ketara adalah peningkatan kadar nadi rehat. Selain itu, kadar nadi semasa bersenam juga turut meningkat. *Overtraining* jenis ini lebih selalu berlaku dalam kalangan atlet yang memfokuskan kepada latihan jenis pecutan dan kuasa, atlet yang berlatih dengan sangat kerap, gaya hidup yang menyumbang kepada tekanan, dan selalunya atlet-atlet yang mempunyai gabungan faktor-faktor ini (Maffetone, 2015).

RUJUKAN

Abernethy, B., Kippers V., Hanrahan, S., Pandy, M., McManus, A., Mackinnon, L. (2005). *The biophysical foundations of human movement (2nd ed.)*. IL: Human Kinetics.

Achten J, Jeukendrup AE. (2003). *Heart rate monitoring: applications and limitations.* Sports Med 2003; 33: 517–38

Adabag, S., & Pierpont, GL. (2013). Exercise heart rate recovery: Analysis of methods and call for standards. *Heart (British Cardiac Society). 99.* 10.1136/heartjnl-2013-303863.

Akubat I, Abt G. (2011). Intermittent exercise alters the heart rate-blood lactate relationship used for calculating the training impulse (TRIMP) in team sport players. J Sci Med Sport. 2011 May;14(3):249-53. doi: 10.1016/j.jsams.2010.12.003

Alhborg, G. (1985). Mechanisms for glycogenolysis in nonexercising human muscle during and after exercise. *American Journal of Physiology 248*: E540-E545.

Arai, Y., Saul, JP., Albrecht, P., Hartley LH., Lilly, LS., Cohen, RJ., & Colucci, WS. (1989). Modulation of cardiac autonomic activity during and immediately after exercise. *American Journal of Physiology 256*, H132-H141.

Armstrong, LE., Van Heest, JL. (2002). The unknown mechanism of the overtraining syndrome: clues from depression and psychoneuroimmunology. *Sports Medicine 32*(3):185-209.

Arnold, BC., Gansneder BM., & Perrin, DH. (2005). *Research methods in athletic training.* Philadelphia: FA Davis Company.

Aubert AE, Seps B, Beckers F. (2003). *Heart rate variability in athletes.* Sports Med 2003; 33 (12): 889-919.

Aunola, S., & Rusko, H. (1984). Reproducibility of aerobic and anaerobic thresholds in 20-50 year old men. *European Journal of Applied Physiology and Occupational Physiology 53*: 260-266.

Azevedo PHSM, Oliveira JC, Aguiar AP, Poian PAFO, Marques AT, Baldissera V. Estudo do limiar de lactato em exercício resistido: rosca direta e mesa flexora. Lecturas: EF y Desportes. 2005;10(87):1.(20).

Aziz, AR., Kilding, AE., & Teh, KC. (2006). Heart rate recovery post-maximal exhaustive exercise and its correlation with maximal aerobic power in trained team sport athletes. *Journal of Exercise Science & Fitness, 4*(2), 110-116.

Bacon L, Kern M. Evaluating a test protocol for predicting maximum lactate steady state. J Sports Med Phys Fitness. 1999;39(4):300-8.

Bangsbo J. The physiology of soccer—with special reference to intense intermittent exercise. Acta Physiol Scand1994;151(Suppl. 619):1–155.

Bangsbo, J., Krustrup, P., González-Alonso, J., & Saltin, B. (2001). ATP production and efficiency of human skeletal muscle during intense exercise: effect of previous exercise. *American Journal of Physiology & Endocrinology Metabolism*; *280*: E956—64.

Barron, GL., Noakes, TD., Levy, W., Smith, C., & Millar, RP. (1985). Hypothalamic dysfunction in overtrained athletes. *Journal of Clinical Endocrinology and Metabolism* 1985; 60: 803-6.

Barron, L., Camelin, F. X., & Berthoin, S. (2008). Reliability of postexercise heart rate recovery. *International Journal of Sports Medicine, 29*(3), 238–243.

Barros CLM, Agostini GG, Garcia ES, Baldissera V. Limiar de lactato em exercí- cio resistido. Ver Motriz. 2004;10(1):31-6.

Beneke R, Leithauser RM, Hutler M Dependence of the maximal lactate steady state on the motor pattern of exercise. Br J Sports Med 2001; 35: 192-6.

Beneke, R. (1995). Anaerobic threshold, individual anaerobic threshold, and maximal lactate steady state in rowing. *Medicine & Science in Sports & Exercise 27*: 863-867.

Beneke, R. (2012). Training at lactate threshold: Science based concept or irrational myth? *Journal of Sports and Medicine in Doping Studies 2*:3

Beneke, R., & von Duvillard, SP. (1996). Determination of maximal lactate steady state response in selected sports events. *Medicine & Science in Sports & Exercise 28*: 241—6.

Beneke, R., Hütler, M., & Leithäuser, RM. (2000). Maximal lactate steady state independent of performance. *Medicine & Science in Sports & Exercise 32*: 1135-1139.

Beneke, R., Leithauser, RM., & Hutler, M. (2001). Dependence of the maximal lactate steady state on the motor pattern of exercise. *British Journal of Sports Medicine 35*: 192-6.

Beneke, R., Leithäuser, RM., & Hütler, M. (2001). Dependence of the maximal lactate steady state on the motor pattern of exercise. *British Journal of Sports Medicine 35*: 192-196.

Bertuzzi, RC., Franchini, E., Ugrinowitsch, C., Kokubun, E., Lima-Silva, AE., Pires, FO., Nakamura, FY., & Kiss, MA. (2010). Predicting MAOD using only a supramaximal exhaustive test. *International Journal of Sports Medicine 31*:477e481.

Billat VL, Slawinski J, Bocquet V, et al. Intermittent runs at the velocity associated with maximal oxygen uptake enables sub- jects to remain at maximal oxygen uptake for a longer time than intense but submaximal runs. Eur J Appl Physiol 2000;81:188– 96.

Billat, LV. (1996). Use of blood lactate measurements for prediction of exercise performance and for control of training. Recommendations for long-distance running. *Sports Medicine 22*: 157-75.

Birrer, D., Lienhard, D., Williams, C. A., Röthlin, P., & Morgan, G. (2013). Prevalence of non-functional overreaching and the overtraining syndrome in Swiss elite athletes. *Schweizerische Zeitschrift Fur Sportmedizin Und Sporttraumatologie, 61*(4), 23–29.

Bishop, D., Edge, J., Thomas, C., & Mercier, J. (2008). Effects of high-intensity training on muscle lactate transporters and postexercise recovery of muscle lactate and hydrogen ions in women. *American Journal of Physiology – Regulatory, Integrative, & Comparative Physiology 295*:R1991—8.

Borrese, J., & Lambert, MI. (2007). Changes in heart rate recovery on response to acute changes in training load. *Europeanan Journal of Applied Physiology, 101*, 503-511.

Borresen J, Lambert MI. (2008). *Autonomic control of heart rate during and after exercise - measurements and implications for monitoring training status.* Sports Med 2008; 38 (8): 633-46.

Bosquet L, Merkari S, Arvisais D, Aubert AE. (2008*). Is heart rate a convenient tool to monitor over-reaching? A systematic review of the literature.* Br J Sports Med 2008; 42 (9): 709-14.

Bosquet L, Papelier Y, Leger L, Legros P. (2003). *Night heart rate variability during overtraining in male endurance athletes.* J Sports Med Phys Fitness 2003; 43 (4): 506-12.

Bosquet, L., Gamelin, FX., Berthoin, S. (2008). Reliability of Postexercise Heart Rate Recovery. International Journal of Sports Medicine 2008; 29: 238-243

Bosquet, L., Leger, L., Legros, P. (2001). Blood lactate response to overtraining in male endurance athletes. *European Journal of Applied Physiology. 84*(1-2):107-14.

Bosquet, L., Merkari, S., Arvisais, D., Aubert, A.E. (2008). Is heart rate a convenient tool to monitor over-reaching? A systematic review of the literature. *British Journal of Sports Medicine. 42*(9): 709-714.

Brenner IK, Thomas S, Shephard RJ. (1997). *Spectral analysis of heart rate variability during heat exposure and repeated exercise.* Eur J Appl Physiol 1997; 76: 145-56.

Brooks K, Carter J. (2013). *Overtraining, exercise, and adrenal insufficiency.* J Nov Physiother 2013; 3 (125):11717.

Brooks, G.A. (1985). Anaerobic threshold: review of the concept and directions for future research. *Medicine & Science in Sports & Exercise. 17*: 22–34.

Brooks, G.A. (2000). Intra- and extra-cellular lactate shuttles *Medicine & Science in Sports & Exercise 32*(4):790-9.

Brooks, G.A., Fahey, T.D., White, T.P. (1996). *Exercise physiology: human bioenergetics and its applications, 2nd ed.* Mayfield, Mountain View, CAL.

Brooks, GA. (2009). Cell-cell and intracellular lactate shuttles. *The Journal of Physiology 587*(pt 23):5591-5600.

Brooks, GA. (1991). Current concepts in lactate exchange. *Medicine & Science in Sports & Exercise 23:* 895-906.

Brooks, GA. (1986). The lactate shuttle during exercise and recovery. *Medicine & Science in Sports & Exercise 18:*360e368.

Buchheit M, Simpson MB, Al Haddad H, Bourdon PC, Mendez-Villanueva A. (2012). *Monitoring changes in physical performance with heart rate measures in young soccer players.* Eur J Appl Physiol 2012; 112 (2): 711-23

Buchheit, M., Duche, P., Laursen, PB., & Ratel, S. (2010). Post-exercise heart rate recovery in children: relationship with power output, blood pH, and lactate. *Applied Physiology, Nutrition, & Metabolism, 35*(2), 142-150. doi: 110.1139/H1109-1140.

Buchheit, M., Laursen, PB., & Ahmaidi, S. (2007). Parasympathetic reactivation after repeated sprint exercise. *American Journal of Physiology-Heart and Circulatory Physiology; 293*: H133– H141.

Buchheit, M., Millet, GP., Parisy, A., Pourchez, S., Laursen, PB., & Ahmaidi, S. (2008). Supramaximal training and postexercise parasympathetic reactivation in adolescents. *Medicine & Science in Sports & Exercise; 40*: 362–371.

Buchheit, M., Papelier, Y., Laursen, PB., & Ahmaidi, S. (2007). Noninvasive assessment of cardiac parasympathetic function: postexercise heart rate recovery or heart rate variability? *American Journal of Physiology-Heart and Circulatory Physiology; 293*: H8–H10.

Buchheit, M., Simpson, MB., Al Haddad, H., Bourdon, PC., & Mendez-Villanueva, A. (2011) Monitoring changes in physical performance with heart rate measures in young soccer players. *European Journal of Applied Physiology 112*(2):711-23.

Buchwald, D., & Komaroff, AL. (1991). Review of laboratory findings for patients with chronic fatigue syndrome. *Reviews of Infectious Disease 13*: S12-28.

Budgett, R. (1990). Overtraining syndrome. *British Journal of Sports Medicine; Vol. 24,* No. 4 pg 231-236

Budgett, R. (1998). Fatigue and underperformance in athletes: the overtraining syndrome. *British Journal of Sports Medicine, 32*(2), 107–110.

Cairns, SP. (2006). Lactic acid and exercise performance: Culprit or friend? *Sports Medicine 36*:279-291.

Callister R, Callister RJ, Fleck SJ, Dudley GA. (1990). *Physiological and performance responses to overtraining in elite judo athletes.* Med Sci Sports Exerc 1990; 22 (6): 816-24.

Carter III, R., Watenpaugh, DE., Wasmund, WL., Wasmund, SL., & Smith, ML. (1999). Muscle pump and central command during recovery from exercise in humans. *Journal of Applied Physiology, 87*: 1463- 1469.

Carter JB, Banister EW, Blaber AP. (2003). *Effect of endurance exercise on autonomic control of heart rate.* Sports Med 2003; 33 (1): 33-46.

Cheng, YJ., Lauer, MS., Earnest, CP., Church, TS., Kampert, JB., Gibbons, LW., & Blair. SN. (2003). Heart rate recovery following maximal exercise testing as a predictor of cardiovascular disease and all-cause mortality in men with diabetes. *Diabetes Care 26:* 2052–2057

Christenfeld, N., Glynn, LM., & Gerin, W. (2000). On the reliable assessment of cardiovascular recovery: an application of curve-fitting techniques. *Psychophysiology 37*: 543–550

Christmass, MA., Dawson, B., Passeretto, P., & Arthur, PG. (1999). A comparison of skeletal muscle oxygenation and fuel use in sustained continuous and intermittent exercise. *European Journal of Applied Physiology; 80*:423–35.

Coen, B., Urhausen, A., & Kindermann, W. (2001). Individual anaerobic threshold: method ological aspects of its assessment in running. *International Journal of Sports Medicine*; *22*:8-16.

Cole, CR., Blackstone, EH., Pashkow, FJ., Snader, CE., & Lauer, MS. (1999). Heart-rate recovery immediately after exercise as a predictor of mortality. *New England Journal of Medicine, 341*: 1351-1357.

Cole, CR., Foody, JM., Blackstone, EH., & Lauer, MS. (2000). Heart rate recovery after submaximal exercise testing as a predictor ofmortality in a cardiovascular healthy cohort. *Annals of Internal Medicine; 132*: 552–555

Cousineau D, Ferguson RJ, de Champlain J, Gauthier P, Cote P, Bourassa M. (1977). *Catecholamines in coronary sinus during exercise in man before and after training.* J App Physiol 1977; 43 (5): 801-6.

Coyle, EF., Coggan, AR., Hopper, MK., & Walters, TJ. (1988). Determinants of endurance in well-trained cyclists. *Journal of Applied Physiology 64*: 2622-2630.

Cristi-Montero, C., Rodriguez-Rodriguez, F., Mendoza-Munoz, J., Baronti-Correa, F., Leiva-Olivares, S., Rojas-Hube, M., & Bresciani, G. (2014). Blood lactate removal after a rowing all-out test depends on the active protocol proposed. *Science & Sport 30,* 283-289

Cruz, de RSO., de Aguiar, RA., Turnes, T., Penteado Dos Santos, R., de Oliveira, MFM., & Caputo, F. (2012). Intracellular shuttle: the lactate aerobic metabolism. *The Scientific World Journal 2012*:420984.

D Maryama Daud, Aminuddin Abdul Hamid Karim, Nabishah Mohamad, Noor Aini bin Hamid, & Wan Zurinah Wan Ngah. Acute oxidative stress responses is affected intensity and duration of aerobic exercise.

Daanen, HAM., Lamberts, RP., Kallen, VL., Jin, A., & Van Meeteren, NLU. (2012). A systematic review on heart-rate recovery to monitor changes in training status in athletes. *International Journal of Sports Physiology and Performance 7*(3), 251–260.

Dantas, JL., Doria, C., Rossi, H., Rosa, G., Pietrangelo, T., Fanò-Illic, G., & Nakamura, FY. (2015). Determination of blood lactate training zone boundaries with rating of perceived exertion in runners. *The Journal of Strength & Conditioning Research 29*:315-320.

Darr, KC., Bassett, DR., Morgan, BJ. & Thomas, DP. (1988) Effects of age and training status on heart rate recovery after peak exercise. *American Journal of Physiology 254*, H340-H343.

Dassonville, J., Beillot, J., Lessard, Y., Jan, J., André, AM., Le Pourcelet, C., Rochcongar, P., & Carré, F. (1998). Blood lactate concentrations during exercise: effect of sampling site and exercise mode. *The Journal of Sports Medicine and Physical Fitness 38*: 39-46.

Davies, CTM., Di Prampero, PE., & Cerretelli, P. (1972). Kinetics of cardiac output and respiratory gas exchange during exercise and recovery. *Journal of Applied Physiology; 32*: 618–625

Davis, JA., Rozenek, R., DeCicco, DM., Carizzi, MT., & Pham, PH. (2007). Comparison of three methods for detection of the lactate threshold. *Clical Physiology and Functional Imaging 27*:381-384.

de Miranda Rohlfs, ICP., de Mara, LS., de Lima, WC., & de Carvalho, T. (2005). Relationship of the overtraining syndrome with stress, fatigue, and serotonin. *Revista Brasileira de Medicina Do Esporte 11*, 367–372.

de Oliveira, JC., Baldissera, V., Simões, HG., de Aguiar, AP., de Azevedo, PHM., Poian, PAFdO., & Perez, SEdA. (2006). Identification of the lactate threshold and the blood glucose threshold in resistance exercise. *Revista Brasileira de Medicina do Esporte, 12*(6), 333-338.

de Sousa, NMF., Magosso, RF., Arakelian, VM., Pereira, GB., Domingos, NM., Perez, SEA., & Baldissera, V. (2012). Acid-base balance at lactate threshold in resistance exercise. *Science & Sports 28*, e1 – e7

de Sousa, NMF., Magosso, RF., Pereira, GB., Leite, RD., Arakelian, VM., Montagnolli, AN., Perez, SA., Baldissera, V. (2011). The measurement of lactate thresh- old in resistance exercise: a comparison of methods. *Clinical Physiology and Functional Imaging 3*1:376—81.

Dennis, SC., Noakes, TD., & Bosch, AN. (1992). Ventilation and blood lactate increase exponentially during incremental exercise. *Journal of Sports Science; 10*: 437-49

di Prampero, PE., & Ferretti, G. The energetics of anaerobic muscle metabolism: a reappraisal of older and recent concepts. *Respiration Physiology 118*:103e115.

Dong, JG. (2016). The role of heart rate variability in sports physiology. *Experimental Therapy Medicine 11*(5), 1531-1536.

Dressendorfer, R.H. (1985) Increased morning heart rate in runners: a valid sign of overtraining? *Physiology of Sport Medicine 13* (8), 77-86

Dubouchaud, H., Butterfield, GE., Wolfel, EE., Bergman, BC., & Brooks, GA. (2000). Endurance training, expression, and physiology of LDH, MCT1, and MCT4 in human skeletal muscle. *American Journal of Physiology-Endocrinology and Metabolism 278*: E571-E579.

Dupont, G., Moalla, W., Guinhouya, C., Ahmaidi, S., & Berthoin, S. (2004). Passive versus active recovery during high-intensity intermittent exercises. *Medicine & Science in Sports & Exercises 36*:302—8.

Dupont, G., Moalla, W., Matran, R., & Berthoin, S. (2007). Effect of short recovery intensities on the performance during two Wingate tests. *Medicine & Science in Sports & Exercises 39*:1170—6.

Edwards, RHT., Melcher, A., Hesser, CM., & Wigertz, O. (1971). Blood lactate concentrations during intermittent and continuous exercise with the same average power output. *Muscle metabolism during exercise: advances in experimental medicine and biology*. New York: Plenum Press; p. 425–8.

Faul, F., Erdfelder, E., Lang, AG., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*, 175-191.

Felippe, LC., Ferreira, GA., De-Oliveira, F., Pires, FO., & Lima-Silva, AE. (2017). Arterialized and venous blood lactate concentration difference during different exercise intensities. *Journal of Exercise Science & Fitness 15* 22-26

Feliu, J., Ventura, JL., Segura, R., Rodas, G., Riera, J., Estruch, A., Zamora, A., & Capdevila, L. (1999). Differences between lactate concentration of samples from ear lobe and the finger tip. *Journal of Physiology and Biochemistry 55*:333-339

Fernandes, AL., Lopes-Silva, JP., Bertuzzi, R., Casarini, DE., Arita, DY., Bishop, DJ., & Lima-Silva, AE. (2014). Effect of time of day on performance, hormonal and metabolic response during a 1000-M cycling time trial. *Public Libarry of Science ONE 9*:e109954.

Fitts, R.H. (1994). Cellular mechanisms of muscle fatigue. *Physiology Reviews 74*:49–94.

Forster, HV., Dempsey, JA., Thomson, J., Vidruk, E., DoPico, GA. (1972). Estimation of arterial PO2, PCO2, pH, and lactate from arterialized venous blood. *Journal of Applied Physiology 32*:134e137.

Forsyth, JJ., & Farrally, MR. (2000). A comparison of lactate concentration in plasma collected from the toe, ear, and fingertip after a simulated rowing exercise. *British Journal of Sports & Medicine 34*:35-38.

Forsyth, JJ., & Reilly, T. (2004). Circadian rhythms in blood lactate concentration during incremental ergometer rowing. *European Journal of Applied Physiology 92*:69—74.

Foster, C., Lehman, M. (1997). *Overtraining syndrome. In: Running injuries. (ed.).* Philadelphia; 1997:173-88.

Foster, C., Snyder, AC., Thompson, NN., & Kuettel, K. (1988). Normalization of the blood lactate profile in athletes. *International Journal of Sports Medicine 9*: 198-200.

Foster, C., Netzer, N., Lormes, W., Steinacker, JM., Liu, Y., Opitz-Gress, A., & Gastmann, U. (1998). *Physiological response to short- and long-term overtraining in endurance athletes.* In: RB Kreider ACF, O'Toole ML, editors. Overtraining in sport. Champaign, IL; 1998:19-46.

Fry, A.C., Kraemer, W.J. (1997). Resistance exercise overtraining and overreaching: Neuroendocrine responses. *Sports Medicine 23*(2):106-29.

Fry, AC., Kraemer, WJ., Koziris, LP., Lynch, JM., & Triplettl, NT. (1994). Does short-term near-maximal intensity machine resistance training induce overtraining? *Medicine and Science in Sport and Exercise, 8*(3), 188–191.

Fry, RW., Grove, JR., Morton, AR., Zeroni, PM., & Keast, D. (1994). Psychological and immunological correlates of acute overtraining. *British Journal of Sports Medicine 28*: 241-246.

Fry, RW., Morton, AR., & Keast, D. (1991). Overtraining in athletes: an update. *Sports Medicine 12*(1):32-65.

Fry, RW., Morton, AR., Garcia-Webb, P., Crawford, GP., & Keast, D. (1992). Biological responses to overload training in endurance sports. *European Journal of Applied Physiology 64*(4):335-34.

Gaesser GA, Poole DC, Gardner BP. Dissociation between VO2 max and ven tilatory threshold responses to endurance training. *European Journal of Applied Physiology*, *53*: 242-7.

Gaesser, GA., Ward, SA., Baum, VC., & Whipp, BJ. (1992). The effects of infused epinephrine on the excess oxygen uptake of heavy exercise in humans. *Federation of American Societies for Experimental Biology Journal 6*: A1236.

Gamelin FX, Berthoin S, Sayah H, Libersa C, Bosquet L. (2007). *Effect of training and detraining on heart rate variability in healthy young men*. Int J Sports Med 2007; 28: 564–70.

Gardiner, PF. (2001). *Neuromuscular aspects of physical activity*. USA: Human Kinetics.

Gevers, W. (1977). Generation of protons by metabolic processes in heart cells. *Journal of Molecular and Cellular Cardiology*, *9*: 867-74.

Ghosh, AK. (2004). Anaerobic threshold: Its concept and role in endurance sport. *Malaysian Journal of Medical Sciences, Vol. 11,* No. 1, January 2004 (24-36)

Giri, MKW., Doewes, M., Jatmika, HM., Purnomo, KI., Setiawan, KH., & Wibowo, IPA. (2017). Myocardial pathological changes in overtraining exercise. *IOP Conf. Series: Materials Science and Engineering 180* (2017) 012168.

Gladden, LB. (2004). Lactate metabolism: a new paradigm for the third millennium. *The Journal of Physiology 588*:5—30.

Gleeson, M. (2002). Biochemical and immunological markers of overtraining. *Journal of Sports Science and Medicine 2*:31-41.

Gleeson, M., Blannin, AK., Walsh, NP., Field, CN., & Pritchard, JC. (1998). Effect of exercise-induced muscle damage on the blood lactate response to incremental exercise in humans. *European Journal of Applied Physiology*; *77*: 292-5.

Glynn, LM., Christenfeld, N., & Gerin, W. (2002). The role of rumination in recovery fromreactivity: cardiovascular consequences ofemotional states. *Psychosomatic Mediicne; 64:* 714–726

Grafman, J., Johnson, R., Scheffers, M. (1991). Cognitive and mood-state changes in patients with chronic fatigue syndrome. *Reviews of Infectious Disease 13*: S45-52.

Granier, P., Dubouchaud, H., Mercier, B., Mercier, J., Ahmaidi, S., & Préfaut, C. (1996). Lactate uptake by forearm skeletal muscles during repeated periods of short-term intense leg exercise in humans*European Journal of Applied Physiology and Occupational Physiology 72*:209e214.

Gregory, J., Johns, DP., & Walls, JT. (2007). Relative vs. absolute physiological measures as predictors of mountain bike cross-country race performance. *Journal of Strength & Conditioning Research 21*:17-22.

Griffin. A., Unnithan. V. (1993). Overtraining in child athletes. *Journal of Bodywork and Movement Therapies.* 3(2):92-96.

Hackney, CH., Pearman III, SN., Nowacki, JM. (1990). Physiological profiles of overtrained and stale athletes: a review. *Applied Sport Psychology, 2*,21-33 (1990).

Hagberg, JM., Hickson, RC., Ehsani, AA., & Holloszy, JO. (1980). Faster adjustment to and recovery from submaximal exercise in the trained state. *Journal of Applied Physiology; 48*: 218–224

Hagberg, JM., Hickson, RC., McLane, JA., Ehsani, AA., & Winder, WW. (1979). Disappearance of norepinephrine from the circulation following strenuous exercise. *Journal of Applied Physiology 47*, 1311–1314.

Hall, MM., Rajasekaran, S., Thomsen, TW., Peterson, AR. (2016) Lactate: friend or foe. *Advanced Sports Medicine Concepts and Cotroversies PM R 8* 68-515

Halson SL, Bridge MW, Meeusen R, et al. (2002). *Time course of performance changes and fatigue markers during intensified training in trained cyclists.* J Appl Physiol 2002; 93 (3): 947-56

Hoogeveen, AR., & Schep, G. (1997). The plasma lactate response to exercise and endurance performance: relationships in elite triathletes. *International Journal of Sports Medicine 18*: 526-30.

Hooper, SL., & Mackinnon, LT. (1995). Monitoring overtraining in athletes. *Sports Medicine, 20,* 321-7.

Hooper, SL., Mackinnon, LT., Gordon, RD., & Bachmann, AW. (1993) Hormonal responses of elite swimmers to overtraining. *Medicine & Science in Sports & Exercise 25*(6):741-7.

Hooper, SL., Mackinnon, LT., Howard, A., Gordon, RD., & Bachmann, AW. (1995). Markers for monitoring overtraining and recovery. *Medicine and Science in Sports and Exercise, 27*(1), 106-112.

Hug, M., Mullis, PE., Vogt, M., Ventura, N., & Hoppeler, H. (2003). Training modalities: overreaching and overtraining in athletes, including a study of the role of hormones. *Best Practice & Resarch: Clinical Endocrinology & Metabolism Vol. 17*, No. 2, pp. 191 – 209.

Hull, KL. & McConnell, TH. (2011). *Study guide to accompany: human form, human function. Essentials of anatomy & physiology*. Lippincott Williams & Wilkins.

Hurley, BP., Hagberg, JM., Allen, WK., Seals, DR., Young, JC., Cuddihee, RW., & Holloszy, J.O. (1984). Effect of training on blood lactate levels during submaximal exercise. *Journal of Applied Physiology 56*: 1260 – 1264.

Hynynen, A., Uusitalo, A., Konttinen, N. , Rusko, H. (2006). Heart rate variability during night sleep and after awakening in overtrained athletes. *Medicne & Science in Sports & Exercise. 38*(2):313-317.

Imai, K., Sato, H., Hori, M,. Kusuoka, H., Ozaki, H., Yokoyama, H., Takeda, H., Inoue, M., & Kamada T. (1994). Vagally mediated heart rate recovery after exercise is accelerated in athletes but blunted in patients with chronic heart failure. *Journal of the American College of Cardiology. 24*: 1529-1535, 1994.

Impellizzeri, FM., Rampinini, E., & Marcora, SM. (2005). Physiological assessment of aerobic training in soccer. *Journal of Sports Science; 7*(6):583–92.

Ivy, J.L. (2004). Regulation of muscle glycogen repletion, muscle protein synthesis and repair following exercise. *Journal of Sports Science and Medicine 3*(3): 131–138.

Ivy, J.L., Costill, D.L., Van Handel, P.J., Essig, D.A., Lower, R.W. (1981). Alteration in the lactate threshold with changes in substrate availability. *International Journal of Sports Medicine 2*: 139-142.

Jacobs I. (1986). Blood lactate implications for training and sports performance. *Sports Medicine 3*: 10-25.

James, DVB., Munson, SC., Maldonado-Martin, S., & Croix, MBADS. (2012). Heart rate variability: Effect of exercise intensity on post-exercise response. *Research Quarterly for Exercise and Sport, 83(*4), 533-9.

Javorka, M., Žila, I., Balhárek, T., & Javorka, K. (2002). Heart rate recovery after exercise: relations to heart rate variability and complexity. *Brazilian Journal of Medical and Biological Research 35*: 991 – 100.

Jeukendrup, A.E., & Hesselink MKC. (1994). Overtraining: what do lactate curve tells us? *British Journal of Sports Medicine 2*: 139 – 142.

Jeukendrup, AE., Hesselink, MKC., Snyder, AC., Kuipers, H., & Keizer, HA. (1992). Physiological changes in male competitive cyclists after two weeks of intensified training. *International Journal of Sports Medicine 13*: 534-41.

Johnson, M.B., Thiese, S.M. (1992). A review of overtraining syndrome-recognizing the signs and symptoms. Journal of Athletic Training. 1992;27(4):352-354.

Jones, AM., & McConnell, AM. (1999). Effect of exercise modality on oxygen uptake kinetics during heavy exercise. *European Journal of Applied Physiology 80*: 213-9

Jouven, X., Empana, JP., Schwartz, PJ., Desnos, M., Courbon, D., & Ducimetiere, P. (2005). Heart rate profile during exercise as a predictor of sudden death. *The New England Journal of Medicine; 352*: 1951–1958

Jürimäe, T., Perez-Turpin, JA., Cortell-Tormo, JM., Chinchilla-Mira, IJ., Cejuela-Anta, R., Mäestu, J., Purge, P., & Jürimäe, J. (2010). Relationship between rowing ergometer performance and physiological responses to upper and lower body exercises in rowers. *Journal of Science and Medicine in Sport 13*:434—7.

Kannankeril, PJ. & Goldberger, JJ. (2002). Parasympathetic effects on cardiac electrophysiology during exercise and recovery. American *Journal of Physiology – Heart and Circulatory Physiology 282*: H2091-H2098, 2002.

Kannankeril, PJ., Le, FK., Kadish, AH., & Goldberger, JJ. (2004). Parasympathetic effects on heart rate recovery after exercise. *Journal of Investigative Medicine. 52*: 394-401, 2004.

Karlsson, J. (1997). *Antioxidants and exercise*. USA: Human Kinetics.

Kasikcioglu, E., Oflaz, H., Oncul, A., Kayserilioglu, A., Umman, S., & Nisanci, Y. (2008). The trivest in overreaching syndrome: Cardiac fatigue, muscular weakness, and vascular dysfunction. *International Journal of Cardiology, 127*(3), 417-419.

Kellman, M. (2010). Preventing overtraining in athletes in high-intensity sports and stress/ recovery monitoring. *Scandinavian Journal of Medicine and Science in Sports, 20*(SUPPL. 2), 95–102.

Kentta, G., & Hassmen, P. (1998). Overtraining and recovery: a conceptual model. *Sports Medicine 26*(1):1-16.

Kentta. G., Hassmen, P., Raglin, J.S. (2001). Training practices and overtraining syndrome in Swedish age-group athletes. *International Journal of Sports Medicine 22*(6):460-465

Kindermann, W., Simon, G., & Keul J. (1979). The significance of the aerobic-anaerobic transition for the determination of work load intensities during endurance training. *European Journal of Applied Physiolgy and Occupational Physiology 42*:25-34.

Koutedakis, Y., & Sharp, NC. (1998). Seasonal variations of injury and overtraining in elite athletes. *Clinical Journal of Sport Medicine; 8*(1):18-21

Kreher, JB., & Schwartz, JB. (2012). Overtraining syndrome: a practical guide. *Sports Health, 4*(2), 128–138.

Kreider, R., Fry, AC., O'Toole, M. (1998). *Overtraining in sport: terms, definitions, and prevalence.* Champaign, IL: Human Kinetics.

Kuipers H. (1998). *Training and overtraining: An introduction.* Med Sci Sports Exerc 1998; 30 (7): 1137 -9.

Kuipers, H. and Keizer, HA. (1998). Overtraining in elite athletes. Review and directions for the future. *Sports Medicine, 6*(2): 79-92.

Lambert, CP., & Flynn, MG. (2002). Fatigue during high-intensity intermittent exercise: application to bodybuilding. *Sports Medicine; 32*(8):511—22.

Lamberts, RP., Rietjens, GJ., Tijdink, HH., Noakes, TD,. & Lambert, MI. (2010). Measuring submaximal performance parameters to monitor fatigue and predict cycling performance: a case study of a world-class cyclo-cross cyclist. *European Journal of Apllied Physiology 108*:183-90.

Lamberts, RP., Swart, J., Capostagno, B., Noakes, TD., & Lambert, MI. (2009). Heart rate recovery as a guide to monitor fatigue and predict changes in performance parameters. *Scandinavian Journal of Medicine & Science in Sports. 10*:449-457.

Lamberts, RP., Swart, J., Woolrich, RW., Noakes, TD., & Lambert, MI. (2009). Measurement error associated with performance testing in well-trained cyclists; application to the precision of monitoring changes in training status. *International Journal of Sports Medicine; 10:* 33–44.

Lane, AM. & Lovejoy, DJ. (2001). The effects of exercise on mood changes: the moderating effect of depressed mood. *The Journal of Sports Medicine and Physical Fitness, 41* (4), 539-545.

Latash, ML., & Laczko, J. (1998). *Progress in motor control: Bernstein's traditions in movement studies.* USA: Human Kinetics.

Lauer, MS. (2003). Is heart rate recovery a modifiable risk factor? *Journal of Cardiopulmonary Rehabilitation; 23*:88-9

Lehmann M, Baumgartl P, Wiesenack C, et al. (1992). *Training- overtraining: influence of a defined increase in training volume vs training intensity on performance, catecholamines and some metabolic parameters in experienced middle- and long-distance runners.* Eur J Appl Physiol Occup Physiol 1992; 64 (2): 169-77

Lehmann, M. (1988). Sympathetic activity in relation to performance diagnostics, training and overtraining. *International Journal of Sports Medicine, 9*: 390.

Lehmann, M., Foster, C., Dickhuth, HH., & Gastmann, U. (1998). Autonomic imbalance hypothesis and overtraining syndrome. *Medicine and Science in Sports and Exercise 30*(7):1140-1145.

Lehmann, M., Gastmann, MD., Petersen, KG., Bach, IN., Seidel, A., Khalaf, AN., Fischer, S., Keul, J. (1992). Training-overtraining: performance and hormone levels after a

de®ned increase in training volume versus training intensity in experienced middle- and long-distance runners. *British Journal of Sports Medicine 26*: 233±242

Lehmann, M., Foster, C., & Keul, J. (1993). Overtraining in endurance athletes: a brief review. *Medicine and Science in Sports and Exercise. 25*(7):854-62.

Lehmann, MJ., Lormes, W., Opitz-Gress, A., Steinacker, JM., Netzer, N., Foster, C., & Gastmann, U. (1997). Training and overtraining: an overview and experimental results in endurance sports. *Journal of Sports Medicine and Physical Fitness; 37*(1):7-17.

Leuenberger, U., Sinoway, L., Gubin, S., Gaul, L., Davis, D., & Zelis, R. (1993). Effects of exercise intensity and duration on norepinephrine spillover and clearance in humans. *Journal of Applied Physiology. 75*: 668-674, 1993.

Levy, W.C., Cerqueira, M.D., Harp, G.D., Johannessen, K.A., Abrass, I.B., Schwartz, R.S. and Stratton, J.R. (1998) Effect of endurance exercise training on heart rate variability at rest in healthy young and older men. The American Journal of cardiology 82, 1236-1241.

Lindinger, MI., Kowalchuk, JM., & Heigenhauser, GJ. (2005). Applying physicochemical principles to skeletal muscle acid-base status. *American Journal of Physiology-Regulatory, Integrative, and Comparative Physiology; 289*:R891-R894; author reply R904-R910.

Lloyd, AR., Wakefield, D., Boughton, CR., & Dwyer, JM. (1989). Immunological abnormalities in the chronic fatigue syndrome. *Medical Journal Australia 1551*:122-4.

Loat, CE., & Rhodes, EC. (1993). Relationship between the lactate and ventilatory thresholds during prolonged exercise. *Sports Medicine; 15*: 104-15

Londeree, BR. (1997). Effect of training on lactate/ventilatory thresholds: A meta-analysis. *Medicine & Science in Sports & Exercise; 29*:837-843.

Maassen, N., & Busse, BW. (1989). The relationship between lactic acid and work load: a measure for endurance capacity or an indicator of carbohydrate efficiency? *European Journal of Applied Physiology 58*: 728 – 737.

MacIntosh, BR., Esau, S., & Svedahl, K. (2002). The lactate minimum test for cycling: estima tion of the maximal lactate steady state. *Canada Journal of Applied Physiology; 27*(3):232-49.

Mackinnon, LT. & Hooper, S. (1991) Overtraining – state of the art review. *National Sports Research Centre, Department of Human Movement Studies, University of Queensland*. Page-8.

Mackinnon, LT. (2000). Overtraining effects on immunity and performance in athlete. *Immunology and Cell Biology 79*:502-509.

Mackinnon, LT., & Hooper, SL. (1994). Musculoskeletal immune system responses to exercise of varying intensity and during overtraining. *International Journal of Sports Medicine 15:* S179-S183.

MacMillan, JS., Davis, LL., Durham, CF., & Matteson, ES. (2006). Exercise and heart rate recovery. *Heart & Lung Vol. 35*, No. 6

MacRae, HH., Noakes, TD., & Dennis, SC. (1995). Effects of endurance training on lactate removal by oxidation and gluconeogenesis during exercise. *Pflugers Archive – European Journal of Physiology; 430*: 964-70.

Maffetone, P. (2015). *The overtraining syndrome*. Retrieved from https://philmaffetone.com/the-overtraining-syndrome/ on August 20th 2016.

Makivić B, Djordjević Nikić M, Willis MS. (2013). *Heart rate variability (HRV) as a tool for diagnostic and monitoring performance in sport and physical activities.* J Exerc Physiol online 2013; 16(3): 103-31.

Margonis, K., Fatouros, I. G., Jamurtas, A. Z., Nikolaidis, M. G., Douroudos, I., Chatzinikolaou, A., & Kouretas, D. (2007). Oxidative stress biomarkers responses to physical overtraining: Implications for diagnosis. *Free Radical Biology and Medicine, 43*(6), 901–910.

Margonis, K., Fatouros, IG., Jamurtas, AZ., Nikolaidis, MG., Douroudos, I., Chatzinikolaou, A., Mitrakou, A., Mastorakos, G., Papassotiriou, I., Taxildaris, K., & Kouretas, D. (2007). Oxidative stress biomarkers responses to physical overtraining: implications for diagnosis. *Free Radical Biology & Medicine; 43*(6):901-910.

Masterson, JE., & Schwartz, SV. (2016). The enzyme reaction catalyzed by lactate dehydrogenase exhibits one dominant reaction path. *Chemical Physiology* 442(17): 132-136.

Matelot D, Schnell F, Kervio G, Thillaye du Boullay N, Carre F. Athlete's bradycardia may be a multifactorial mechanism. J Appl Physiol 2013; 114 (12): 1755-6.

Matos, NF., Winsley, RJ., & Williams, CA. (2011). Prelevance of non-functional overreaching/overtraining in young English athletes. *Medical and Science in Sports and Exercise; 43*(7):1287-1294

Mazzeo, RS., & Marshall, P. (1989). Influence of plasma catecholamines on the lactate threshold and the critical power. *Journal of Applied Physiology 67*: 1319-1322.

McAinch, AJ., Febbraio, MA., Parkin, JM., Zhao, S., Tangalakis, K., Stojanovska, L., & Carey, MF. (2004). Effect of active versus passive recovery on metabolism and performance during subsequent exercise. *International Journal of Sport Nutrition and Exercise Metabolism 14*:185—96.

McEvoy, JD., & Jones, NL. (1975). Arterialized capillary blood gases in exercise studies. *Medicine & Science in Sports & Exercise; 7*:312e315.

McMillan, K., Helgerud, J., Macdonald, R., & Hoff, J. (2005). Physiological adaptations to soccer specific endurance training in professional youth soccer players. *British Journal of Sports Medicine; 39*(5):273–7

McNair, DM., Lorr, M., & Droppleman, LF. (1971). Manual for the profile of mood states. San

Meehan, HL., Bull, SJ., Wood, DM., & James, DVB. (2004). The overtraining syndrome: a multicontextual assessment. *The Sport Psychologist, 18*, 154-171 2004. Human Kinetics Publishers, Inc.

Meeusen R, Duclos M, Foster C, et al. (2013). *Prevention, diagnosis, and treatment of the overtraining syndrome: joint consensus statement of the European College of Sport Science and the American College of Sports Medicine.* Med Sci Sports Exerc 2013; 45(1): 186-205.

Meeusen, R., Duclos, M, Gleeson, M., Nieman, D., Raglin, J., Rietjens, G., Steinacker, J., & Urhausen, A. (2006). Prevention, diagnosis, and treatment of the overtraining syndrome. *Eurpean Journal of Sport Science; 6*(1):1-14.

Meeusen, R., Piacentini, MF., Busschaert, B., Buyse, L., De Schutter, G., & Stray-Gundersen, J. (2004). Hormonal responses in athletes: the use of a two bout exercise protocol to detect subtle differences in (over)training status. *European Journal of Applied Physiology; 91*(2-3):140-6.

Menzies, P., Menzies, C., McIntyre, L., Paterson, P., Wilson, J., & Kemi, OJ. (2010). Blood lactate clearance during active recovery after an intense running bout depends on the intensity of the active recovery. *Journal of Sports Science; 28*:975—82.

Meur, YL., Buccheit, M., Aubry, A., Coutts, AJ., & Hausswirth, C. (2015). Assessing overreaching with heart rate recovery: what is the minimal intensity required? *International Journal of Sports Physiology and Performance; 12*(4):569-573.

Miller, DK. (2002). *Measurement by the physical educator: why and how (4th ed).* New York: McGraw-Hill.

Mooren, F.C., & Volker, K. (2005). *Molecular and cellular exercise physiology.* Champaign, IL: Human Kinetics.

Moran, LA., Scrimgeour, G., Horton, RH., Perry, M., & Rawn, J. (2012*). Principles of biochemsitry (5th ed.).* USA: Pearson Education Inc.

Moran, P., Prichard, JG., Ansley, L., & Hawtson, G. (2012). The influence of blood lactate sample site on exercise prescription. *Journal of Strength & Conditioning Research; 26*:563e567.

Morgan, WP., Brown, DR., Raglin, JS., O'Connor, PJ., & Ellickson, KA. (1987). Psychological monitoring of overtraining and staleness. *British Journal of Sports Medicine; 21*(3):107-14.

Mostoufi-Moab S, Widmaier EJ, Cornett JA, Gray K, Sinoway LI. (1998). *Forearm training reduces the exercise presser reflex during ischemic rhythmic handgrip.* J Appl Physiol 1998; 84 (1): 277-83.

Mullis. R., Capbell IT., Wearden AJ, Morriss, RK., & Pearson, D.J. (1999). Randomised, double-blind, placebo-controlled treatment trial of fluoxetine and graded exercise for chronic fatigue syndrome. *British Journal of Sports Medicine*; *33*:352-356.

Na, D., Bai, S., Oguri, K., Kato, Y., Matsumoto, I., Kawase, H., & Matsuoka, T. (2005). Heart rate recovery after exercise and neural regulation of heart rate variability in 30-40 year old female marathon runners. *Journal of Sports Science and Medicine; 4*, 9-17

Neilan, TG., Yoerger, DM., Douglas, PS., Marshall, JE., Halpern, EF., Lawlor, D., Picard, MH., & Wood, MJ. (2006). Persistent and reversible cardiac dysfunction among amateur marathon runners. *European Heart Journal; 27*:1079–84.

Nicholson, RM., & Sleivert, GG. Indices of lactate threshold and their relationship with 10-km running velocity. *Medicine & Science in Sports & Exercise; 33*:339e342.

Nielsen, HB., Clemmesen, JO., Skak, C., Ott, P., & Secher, NH. (1985(. Attenuated hepatosplanchnic uptake of lactate during intense exercise in humans. *Journal of Applied Physiology; 92*(4): 1677-83.

Nigam AK. (2010). *Resting heart rate and overtraining in athletes.* Int Referred Res J 2010; 2 (21): 38-40.

Nishime, EO., Cole, CR., Blackstone, EH., Pashkow, FJ., & Lauer, MS. (2000). Heart rate recovery and treadmill exercise score as predictors of mortality in patients referred for exercise ECG. *Journal of the American Medical Association, 284*: 1392- 1398.

Noakes, T.D., & St. Clair Gibson, A. (2004). Logical limitations to the "catastrophe" models of fatigue during exercise in humans. *British Journal of Sports Medicine; 38*(5):648-9.

Noakes, TD. (1998). Maximal oxygen uptake: 'classical' versus 'contemporary' viewpoints: a rebuttal. *Medicine & Science in Sports & Exercise; 30*: 1381-98.

Ogonovszky, H., Sasvari, M., Dosek, A., Berkes, I., Kaneko, T., Tahara, S., Nakamoto, H., Goto, S., & Radak, Z. (2005). The effects of moderate, strenuous, and overtraining on oxidative stress markers and DNA repair in rat liver. *Canadian Journal of Applied Physiology; 30*(2):186-195.

Oliveira, AR., Schneider, C., Ribeiro, JL., Deresz, LF., Barp, J., & Belló-Klein, A. (2003). Oxidative stress after three different intensities of running. *Medicine and Science in Sports and Exercise; 35*:S367.

Olivier, S. (2007). Ethics and physiological testing. In Witer, E.M., Jones, A.M., Davison, R.C.R., Bromley, P.D., Mercer, T.H. (2007). Sport and exercise physiology testing guidelines. Vol. 1: Sport testing, pp 30-37. *British Association of Sport and Exercise Science*. New York: Routledge.

Ørtenblad, N., Westerblad, H., & Nielsen, J. (2013). Muscle glycogen stores and fatigue. *The Journal of Physiology Symposium Review. Journal of Physiology.* 591.18 (2013) pp 4405–4413 4405.

Parkin, JM., Carey, MF., Zhao, S., & Febbraio, MA. (1999). Effect of ambient temperature on human skeletal muscle metabolism during fatiguing submaximal exercise. *Journal of Applied Physiology; 86*: 902-8.

Peçanha, T., Silva-Junior, ND., & Forjaz, C.L. (2014). Heart rate recovery: autonomic determinants, methods of assessment and association with mortality and cardiovascular diseases. *Clinical Physiology & Functional Imaging; 34*:327–339.

Pérez-Guisado J. (2010). Sportsmen and pH: the importance of lactate and diet. *Apunts Medicina de l'Esport; 45*:103—7.

Perini R, Veicsteinas A. (2003). *Heart rate variability and autonomic activity at rest and during exercise in various physiological conditions.* Eur J Appl Physiol 2003; 90 (3-4): 317-25.

Perini, R., Orizio, C., Comande, A., Castellano, M., Beschi, M., & Veicsteinas, A. (1989) Plasma norepinephrine and heart rate dynamics during recovery from submaximal exercise in man. *European European Journal of Applied Physiology 58*, 879- 883.

Petibois. C., Cazorla. G., Poortmans. JR., & Deleris, G. (2003). Biochemical aspects of overtraining in endurance sports: the metabolism alteration process syndrome. *Sports Medicine; 33*:83–94.

Pichot V, Busso T, Roche F, et al. (2002). *Autonomic adaptations to intensive and overload training periods: a laboratory study.* Med Sci Sports Exerc 2002; 34 (10): 1660-6.

Pichot V, Roche F, Gaspoz JM, et al. (2000). *Relation between heart rate variability and training load in middledistance runners.* Med Sci Sports Exerc 2000; 32 (10): 1729-36.

Pierpont, GL., & Voth, EJ. (2002). Heart rate recovery from exercise as an index of both parasympathetic and sympathetic activity. *Faseb Journal, 16*(5, 2), A1142.

Pierpont, GL., Stolpman, DR., & Gornick, CC. (2000). Heart rate recovery post-exercise as an index of parasympathetic activity. *Journal of the Autonomic Nervous System 80* 169-174

Piesik, A., Dryja, M., Zawadka-Kunikowska, M, Slomko, J., Kozakiewicz, M., Tafil-Klawe, M., Klawe, JJ., & Zalewski, P. (2017). Importance of fatiguing, overtraining and chronic fatigue in athletes. *Journal of Education, Health and Sport; 7*(9):203-216. eISSN 2391-8306.

Polito, LFT., Figueira, AJ., Miranda, MLJ., Chtourou, H., Miranda, JM., & Brandão, MRF. (2017). Psychophysiological indicators of fatigue in soccer players: a systematic review. *Science and Sports, 32*(1), 1–13.

Portier H, Louisy F, Laude D, Berthelot M, Guezennec CY. (2001). *Intense endurance training on heart rate and blood pressure variability in runners.* Med Sci Sports Exerc 2001; 33 (7): 1120-5.

Powers, SK. & Howley, ET. (2009). *Exercise physiology: theory and application to fitness and performance (7th ed.).* NY: The McGraw-Hill Companies, Inc.

Purvis, D., Gonsalves, S., & Deuster, PA. (2010). Physiological and psychological fatigue in extreme conditions: Overtraining and elite athletes. *Physical Medicine and Rehabilitation*, *2*(5), 442–450.

Pyne, DB., Boston, T., Martin, DT., & Logan, A. (2000). Evaluation of the Lactate Pro blood lactate analyser. *European Journal of Applied Physiology; 82*:112—6.

Ribeiro, LFP., Balakian Jr, P., Malachias, P., & Baldissera, V. Stage length, spline function and lactate minimum swimming speed. *Journal of Sports Medicine and Physical Fitness*; *43*(3):312-8.

Richter, EA., Derave, W., & Wojtasweski, JF. (2001). Glucose, exercise, and insuline: emerging concepts. *Journal of Physiology; 535*(Pt 2):313-322

Riley, PO., Dicharry, J., Franz, J., Della Croce, U., Wilder, RP., & Kerrigan, DC. (2008). A kinematics and kinetic comparison of overground and treadmill running. *Medicine & Science in Sports & Exercise; 40*:1093—100.

Robergs, RA., & Roberts, S. (1997). *Exercise Physiology: Exercise, performance, and clinical applications.* St Louis, MO: Mosby.

Robergs, RA., Ghiasvand, F., & Parker, D. (2004). Biochemistry of exercise-induced metabolic acidosis. *American Journal of Regulatory, Integrative and Comparative Physiology 287*:502-516, 2004.

Robergs, RA., Chwalbinska-Moneta, J., Mitchell, JB., Pascoe, DD., Houmard, J., & Costill, DL. (1990). Blood lactate threshold differences between arterialized and venous blood. *International Journal of Sports Medicine; 11*(6):446-51.

Rowbottom, DG., & Keast, D. (1998). Monitoring and prevention of overreaching and overtraining in endurance athletes. *Overtraining in Sport, 12*, 47–66.

Rowell, LB. (1974). Human cardiovascular adjustments to exercise and thermal stress. *Physiological Reviews; 54*:75e159.

Rowell, LB., & O'Leary, DS. (1990). Reflex control of the circulation during exercise: chemoreflexes and mechanoreflexes. *Journal of Applied Physiology, 69*: 407- 418.

Ryan, A. (1983) Overtraining in atheletes: A round table. *The Physician and Spor Medicine; 11* (6), 93-110

Saltin, B., & Karlsson, J. (1971). Muscle ATP, CP, and lactate during exercise after physical conditioning. In: Pernow, B., Saltin, B. (eds). *Muscle metabolism during exercise.* Plenum Press, New York, 395-399.

Savin, WM., Davidson, DM., Haskell, & WL., (1982). Autonomic contribution to heart rate recovery from exercise in humans. *Journal of Applied Physiology; 53*, 1572–1575.

Schneider, DA., McLellan, TM., & Gass, GC. (2000). Plasma catecholamine and blood lactate responses to incremental arm and leg exercise. *Medicine & Science in Sports & Exercise; 32*: 608-13.

Schwaberger, G., Pessenhofer, H., & Schmid, P. (1985). Relevance of lactate determination in sports medicine. *Wiener Medizinische Wochenschrift: 135*: 234-41.

Shetler, K., Marcus, R., Froelicher, VF., Vora, S, Kalisetti, D., Prakash, M., Do, D., & Myers, J. (2001). Heart rate recovery: validation and methodologic issues. *Journal of the American College of Cardiology; 38*: 1980-1987, 2001.

Smith, CG., & Jones, AM. (2001). The relationship between critical velocity, maximal lactate steady-state velocity and lactate turnpoint velocity in runners. *European Journal of Applied Physiology; 85*:19-26.

Smith, L.L. (2000). Cytokine hypothesis of overtraining: a physiological adaptation to excessive stress? *Medicine & Science in Sports & Exercise; 32*(2):317-31.

Snyder AC., Kuipers, H., Cheng, B., Servais, R., & Fransen, E. (1995). Overtraining following intensified training with normal muscle glycogen. Medicine *& Science in Sports & Exercise; 18*: S54-S55.

Snyder, AC., Jeukendrup, AE., Hesselink, MKC., Kuipers, H., & Foster, C. (1993). A physiological/psychological indicator of overtraining during intensive training. *International Journal of Sports Medicine; 14*: 29 – 32.

Spencer, M., Dawson, B., Goodman, C., Dascombe, B., & Bishop, D. (2008). Performance and metabolism in repeated sprint exercise: effect of recovery intensity. *European Journal of Applied Physiology; 103*:545—52.

Stagno, KM., Thatcher, R., & van Someren, KA. (2007). A modified TRIMP to quantify the in-season training load of team sport players. *Journal of Sports Science; 27*(6):629–34.

Steele, DS., & Duke, AM. Metabolic factors contributing to altered Ca2+ regulation in skeletal muscle fatigue. *Acta Physiologica; 179*:39—48.

Stegmann, H., & Kindermann, W. Comparison of prolonged exercise tests at the individual anaerobic threshold and the fixed anaer- obic threshold of 4 mmol/L lactate. *International Journal of Sports Medicine; 3*: 105-110.

Stray-Gundersen, J., Videman, T., & Snell, PG. (1986). Changes in selected objective parameters during overtraining. *Medicine & Science in Sport & Exercise, 18* (suppl. 2), 54.

Sugawara, J., Murakami, H., Maeda, S., Kuno, S., & Matsuda, M. (2001). Change in post-exercise vagal reactivation with exercise training and detraining in young men. *European Journal of Applied Physiology; 85:* 259-263.

Swart, J., & Jennings, CL. (2004). Use of blood lactate concentration as a marker of training status. *South African Journal of Sports Medicine, Volume 16, Issue 3*, Dec 2004, p. 1 – 5

Syed Arabi Idid. (2002). *Kaedah penyelidikan komunikasi dan sains sosial*. Kuala Lumpur: Dewan Bahasa dan Pustaka.

Terjung, RL., Baldwin, KM, Winder, WW., & Holloszy, J.O. (1974). Glycogen repletion in different types of muscle and in liver after exhausting exercise. *American Journal of Physiology; 226*(6):1387-1391.

Thomson, RL., Bellenger, CR., Howe, PR., Karavirta, L., & Buckley, JD. (2016). Improved heart rate recovery despite reduced exercise performance following heavy training: A within-subject analysis. *Journal of Science and Medicine in Sport*; *19*:255-9.

Tortora, GJ. & Grabowski, SR. (1996). *Principles of anatomy and physiology*. Harper Collins Publisher Inc.

Urhausen A, Kindermann W. (2002). *Diagnosis of overtraining: what tools do we have?* Sports Med 2002; 32: 95–102.

Urhausen, A., Gabriel, H., & Kindermann, W. (1995). Blood hormones as markers of training stress and overtraining. *Sports Medicine; 20*(4):251-76.

Urhausen, A., Gabriel, HH., Weiler, B., & Kindermann, W. (1998). Ergometric and psychological findings during overtraining: a long-term follow-up study in endurance athletes. *International Journal of Sports Medicine; 19*: 114–120.

Uusitalo AL, Uusitalo AJ, Rusko HK. (1998). *Endurance training, overtraining and baroreflex sensitivity in female athletes.* Clin Physiol 1998; 18 (6): 510-20.

Uusitalo AL, Uusitalo AJ, Rusko HK. (2000). *Heart rate and blood pressure variability during heavy training and overtraining in the female athlete.* Int J Sports Med 2000; 21: 45–53.

Valvona, CJ., Fillmore, HL., Nunn, PB., & Pilkington, GJ. (2015). The regulation and function of lactate dehydrogenase A: Therapeutic potential in brain tumor. *Brain Pathology 26* (2016) 3 - 17

Van Hall, G. (2010). Lactate kinetics in human tissues at rest and during exercise. *Acta Physiologica (Oxf); 199*:499-508

Van Schuylenbergh, R., Vanden Eynde, B., & Hespel, P. (2004). Correlations between lactate and ventilatory thresholds and the maximal lactate steady state in elite cyclists. *Internatioan Journal of Sports Medicine; 25*: 403-408.

Verde, T., Thomas, S., & Shephard, RJ. (1992) Potentialmarkers of heavy training in highly trained distance runners. *British Journal of Ssports Medicine; 26:* 167±175

Viera, AJ., & Neutze, DM. (2006). Oxidative stress in training, overtraining and detraining: from experimental to applied research. *Serbian Journal of Experimental and Clinical Research, 17*(4), 343–348.

Vollsted, NK., & Sejersted, OM. (1988). Biochemical correlates of fatigue. *European Journal of Applied Physiology and Occupational Physiology, 57*,336-347

Warren, JH., Jaffe, RS., Wraa, CE., & Stebbins, CL. (1997). Effect of autonomic blockade on power spectrum of heart rate variability during exercise. *American Journal of Physiology, 273*: R495-R502.

Wasserman, K. (1986). The anaerobic threshold: definition, physiological significance and identification. *Advance Cardiology; 35*: 1-23.

Wasserman, K., & McIlroy, MB. (1964). Detecting the threshold of anaerobic metabolism in cardiac patients during exercise. *American Journal of Cardiology; 14*:844—52.

Wasserman, K., Whipp, BJ., Koyl, SN., & Beaver, WL. (1973). Anaerobic threshold and respiratory gas exchange during exercise. *Journal of Applied Physiology; 35*:236-243.

Weltman, A. (1995). The blood lactate response to exercise. *Current issues in exercise science. Monograph no. 4.* Human Kinetics, Champaign, IL.

Wilmore JH, Stanforth P, Gagnon J, et al. (1996). *Endurance exercise training has a minimal effect on resting heart rate: the HERITAGE study.* Med Sci Sports Exerc 1996; 28 (7): 829-35.

Wilmore, J., Costill, D., & Kenney, W. (2008). *Physiology of sport and exercise (4th ed. ed.).* Champaign, IL: Human Kinetics.

Wolf W. (1957). *A contribution to the questions of overtraining.* Sportmed 1957; 2: 35.

Yamamoto, K., Miyachi, M., Saitoh, T., Yioshioka, A., & Onodera, S. (2001). Effects of endurance training on resting and post exercise cardiac autonomic control. *Medicine & Science in Sports & Exercise; 33*: 1496–1502

Yoshiga, CC., & Higuchi, M. (2003). Bilateral leg extension power and fat-free mass in young oarsmen. *Journal of Sports Science; 21*:905—9.

Zavorsky GS. (2000). *Evidence and possible mechanisms of alteled maximum heart rate with endurance training and tapering.* Sports Med 2000; 29 (l): 13-26.

Zeni, AI., Hoffman, MD., & Clifford, PS. (1996). Relationships among heart rate, lactate concentration, and perceived effort for different types of rhythmic exercise in women. *Archives of Physical Medicine and Rehabilitation; 77*: 237-41.

Zhang, JQ., & Ji, LL. (2016). Gender differences in peak blood lactate concentration and lactate removal. *Annals of Sports and Medicine Research 3*(7): 1088.