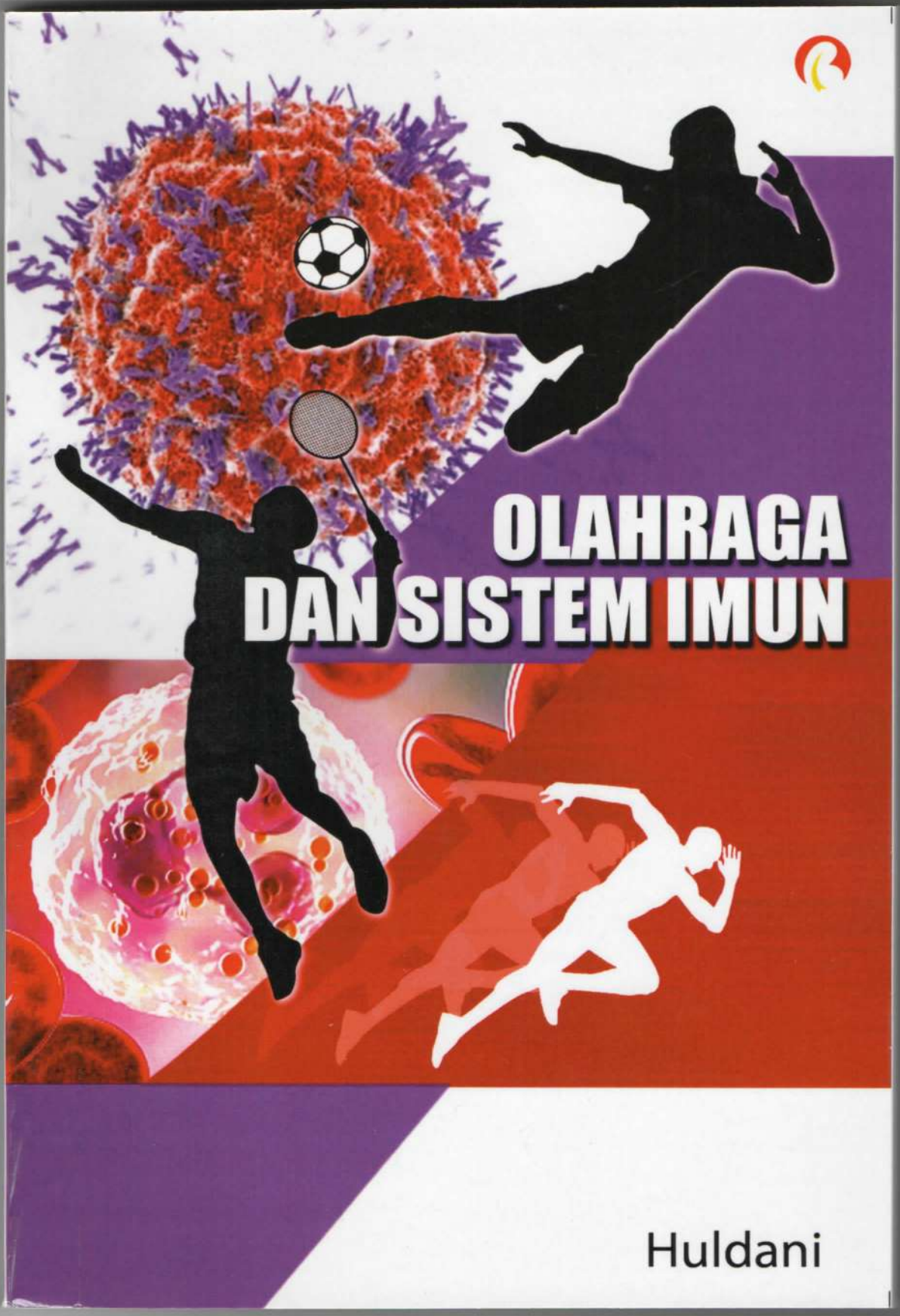


OLAHRAGA DAN SISTEM IMUN

Huldani

OLAHRAGA DAN SISTEM IMUN

Huldani

OLAHRAGA DAN SISTEM IMUN

HULDANI
…

Editor: Wiwin Tyas Istikowati
Tata Letak: Nia Septia Sari
Desain Sampul: Yusuf Libario

Ukuran: viii, 170 hlm, 15.5 x 23 cm
Cetakan Pertama: Mei 2022

ISBN : 978-623-5774-50-3

Penerbit :
CV Banyubening Cipta Sejahtera
Alamat: Jl. Sapta Marga Blok E No. 38 RT 007 RW 003
Guntung Payung, Landasan Ulin, Banjarbaru 70721
E-mail: penerbit.bcs@gmail.com
Keanggotaan IKAPI : 006/KSL/2021

Kata Pengantar

Alhamdulillah segala puji dan syukur penulis panjatkan kepada Allah SWT karena buku riset ini dapat diselesaikan. Buku ini berisi tentang olahraga dan sistem imun yang meliputi komponen dan tes kebugaran jasmani, VO2 Max sebagai indikator sistem kardiovaskuler pada kebugaran jasmani, olahraga dan sistem imunitas tubuh serta metabolisme hormonal.

Penulis menyadari buku ini perlu banyak masukan untuk penyempurnaannya, namun penulis meyakini sepenuhnya bahwa walaupun banyak kekurangan buku ini tetap akan memberikan manfaat bagi pembacanya.

Akhir kata untuk penyempurnaan buku ini maka kritik dan saran sangatlah berguna untuk penulis kedepannya.

Banjarbaru, 15 April 2022

Penulis

Daftar Isi

Daftar Tabel

Daftar Gambar

BAB I
KEBUGARAN JASMANI

A. KOMPONEN KEBUGARAN JASMANI

Komponen Jasmani terdiri dari aspek yang berkaitan dengan kesehatan dan aspek yang berkaitan dengan keterampilan. Kemampuan fisik menjadi komponen utama dalam kegiatan sehari-hari kita karena segala hal yang kita lakukan memerlukan kinerja fisik yang baik untuk mendukung tuntutan aktivitas. Kemampuan fisik yang lebih baik adalah saat seseorang memiliki kemampuan jasmani yang bertingkat-tingkat, atau memiliki cadangan tenaga. Sehingga tubuh tetap dapat melakukan kegiatan fisik ekstra saat diperlukan dalam kondisi darurat dengan menggunakan cadangan energi tersebut. Dengan memiliki kemampuan seperti itu dapat dikatakan bahwa kebugaran jasmani seseorang dalam kondisi baik.

Kebugaran jasmani dapat didefinisikan sebagai suatu kemampuan tubuh untuk menyesuaikan kondisi fisik dengan tingkat beban pekerjaan yang diberikan pada tubuh tanpa menimbulkan efek kelelahan yang berarti setelahnya. Kebugaran jasmani juga dapat diartikan sebagai keadaan tubuh yang mampu menjalankan seluruh kegiatan sehari-hari dengan efektif dan baik namun tidak mengalami kelelahan yang signifikan setelahnya (Sudarno, 1992). Setiap orang

membutuhkan kebugaran jasmani yang baik agar dapat melaksanakan pekerjaan dengan efektif dan efisien tanpa mengalami kelelahan. Pelaksanaan tugas harian kita sangat tergantung pada derajat kebugaran jasmani. Kebugaran jasmani tidak hanya menjadi indikator kesehatan, namun juga salah satu metode yang digunakan dalam mengukur kemampuan seseorang dalam berkegiatan sehari-hari.

Berdasarkan pengertiannya, kebugaran jasmani dapat diklasifikan berdasarkan dua hal berikut:

1. Sehat

   Terbebasnya tubuh segala gangguan penyakit secara fisik dan mental.

2. Bugar

   Kondisi dimana seseorang mampu melakukan kegiatan sehari-hari dengan baik dan semaksimal mungkin, namun masih memiliki cadangan tenaga untuk berkegiatan lain setelahnya tanpa merasa kelelahan.

Teori lain menyebutkan bahwa komponen kebugaran jasmani tergantung dari dua komponen dasar yang meliputi:

1. Kesegaran organik atau *organic fitness*

   Komponen ini meliputi sifat-sifat khusus yang terkait dengan genetik atau keturunan yang diwariskan dari kedua orang tua. Juga dipahami sebagai kesehatan fisik keseluruhan.

2. Kesegaran dinamik atau *dynamic fitness*

Komponen ini memiliki variabel yang lebih banyak berkaitan dengan kesiapan dan kapasitas tubuh untuk bergerak dan bertindak dalam tingkatan tertentu sesuai dengan situasi yang dihadapi.

Dapat disimpulkan bahwa kesegaran organik sulit untuk ditingkatkan karena sudah bersifat genetik, tetapi kesegaran dinamik dapat ditingkatkan melalui latihan fisik yang rutin dan dengan cara yang benar.

Dalam kebugaran jasmani juga ada 3 hal penting yang memengaruhinya, meliputi:

1. Faktor fisik

   Meliputi hal-hal yang berkaitan dengan otot, tulang, dan lemak tubuh.

2. Faktor organ

   Berkaitan dengan efektivitas kinerja sistem jantung dan pembuluh darah, serta sistem pernapasan.

3. Faktor respon otot

   Meliputi hal yang berkaitan dengan kecepatan motorik, kelenturan tubuh, kelemahan, dan kekuatan fisik.

Karena kebugaran jasmani ini sangat vital untuk keseharian manusia, maka kita perlu melakukan upaya untuk mempertahankan dan meningkatkannya, khususnya kesegaran dinamik seperti yang telah dijelaskan di atas. Cara yang dapat dilakukan untuk mencapai tujuan tersebut adalah dengan melakukan latihan kebugaran jasmani secara rutin. Kekuatan, kelenturan, dan keseimbangan tubuh harus terus dilatih

sebagai tiga komponen penting pembentuk kebugaran jasmani. Latihan kekuatan, kelenturan, dan keseimbangan tetap dapat dicapai secara maksimal jika dilakukan dengan cara yang benar, teratur, dan rutin dalam jangka waktu yang lama, meskipun dengan cara yang mudah dan murah.

Komponen kebugaran jasmani meliputi sepuluh hal berikut:

1. Kekuatan (*Strength*)

Kekuatan didefinisikan sebagai kemampuan tubuh seseorang untuk menggunakan ototnya dalam menerima beban selama bekerja. Latihan yang dapat meningkatkan kekuratan otot adalah jenis latihan yang menggunakan beban berat tetapi dilakukan dengan frekuensi sedikit. Bentuk latihan kekuatan misalnya:

a. squat jump: dapat melatih kekuatan otot tungkai dan perut.
b. push up: untuk melatih kekuatan otot lengan
c. sit up: untuk melatih kekuatan otot perut
d. angkat beban: untuk melatih kekuatan otot lengan
e. back up: untuk melatih kekuatan otot perut

2. Daya Tahan (*Endurance*)

Daya tahan diartikan sebagai kemampuan sistem organ tubuh seseorang bekerja secara efektif dan maksimal selama melakukan aktivitas, misalnya sistem kardiovaskular (jantung dan pembuluh darah) serta

sistem respirasi (paru-paru). Contoh latihan yang dapat meningkatkan daya tahan misalnya adalah:

a. lari 2,4 km
b. lari 12 menit
c. lari multistage
d. lari naik turun bukit

3. Daya Otot atau *Muscular Power*

Daya otot dikenal juga dengan istilah daya ledak otot atau *explosive power*. Yakni suatu kemampuan seseorang menggunakan kekuatan penuhnya dalam waktu sesingkat-singkatnya. Beberapa latihan yang dapat meningkatkan kekuatan daya otot adalah:

a. Vertical jump: bertujuan melatih daya ledak otot di bagian tungkai.
b. Front jump: bertujuan melatih kemampuan otot di bagian betis dan tungkai.
c. Side jump: bertujuan melatih daya ledak otot di bagian tungkai dan paha.

4. Kecepatan atau *speed*

Kecepatan adalah kemampuan seseorang untuk melakukan gerakan secara terus-menurus atau berkesinambungan dalam waktu sesingkat-singkatnya. Lari dengan jarak 50-200 meter dapat menjadi salah satu cara meningkatkan kecepatan.

5. Daya Lentur atau *flexibility*

Daya lentur berkaitan dengan efektivitas tubuh manusia menyesuaikan diri dengan gerakan atau aktivitas yang mengandalkan kelenturan tubuh. Beberapa latihan yang dapat melatih daya lentur misalnya:

a. Senam
b. Yoga
c. Olahraga renang

6. Kelincahan atau *agility*

Jika seseorang mampu menyesuaikan diri dengan posisi-posisi tubuh misalnya dari depan ke belakang, atau dari kiri ke kanan, maka dapat dikatakan orang tersebut lincah. Olahraga sepak bola dan bulu tangkis adalah contoh latihan fisik yang membutuhkan kelincahan. Untuk meningkatkannya, dapat dilatih dengan latihan lari zig-zag atau gerakan naik-turun tangga.

7. Koordinasi

Koordinasi memerlukan gerakan yang sigap, insting yang kuat, serta konsentrasi tinggi. Karena komponen ini merupakan kemampuan seseorang untuk menyatukan gerakan tubuh berbeda dalam satu gerakan yang efektif. Cara melatihnya dapat dilakukan dengan melakukan gerakan memantulkan bola pada tembok menggunakan tangan kanan dan menangkapnya kembali menggunakan tangan kiri.

8. Keseimbangan atau *balance*

Keseimbangan adalah kemampuan seseorang mengatur gerakan tubuh dengan baik melalui pengendalian organ dan syaraf otot. Olahraga yang dapat melatih keseimbangan misalnya senam dan loncat indah. Latihan lain misalnya dengan melakukan beberpa gerakan berikut:

a. sikap lilin
b. berjalan di atas balok kayu
c. berdiri dengan tangan sebagai tumpuannya (*head stand*)

9. Ketepatan atau akurasi

Kemampuan ini terlihat dari kemampuan seseorang dalam mengendalikan gerakan sesuai dengan sasaran, misalnya dalam permainan bowling, memanah, dan permainan basket.

10. Reaksi

Reaksi adalah kemampuan seseorang untuk merespon rangsangan atau stimulus dari luar tubuh. Bentuk latihan kebugaran jasmani untuk melatih reaksi adalah latihan lempar dan tangkap bola.

B. TES KEBUGARAN JASMANI

Beberapa cara yang dapat dilakukan dalam penelitian untuk tes kebugaran jasmani adalah:

1. *Field test*

Tes ini praktis karena tidak memerlukan alat khusus. Subyek hanya diminta berlari dalam jarak dan waktu tertentu. Yang sering dilakukan beberapa diantaranya seperti: lari 12 menit, (2) lari 1.5 mil, (3) lari 2,4 km (McNamara dkk, 2013).

2. Lari 12 km

Tes ini bertujuan untuk mengukur daya tahan jantung paru. Fasilitas dan alat yang diperlukan untuk latihan ini adalah:

a. lintasan datar untuk lari,
b. alat pencatat waktu dan
c. pengukur jarak

Petugas memberikan aba-aba lalu peserta tes berjalan/lari sejauh mungkin selama 12 menit, jarak yang berhasil ditempuh dicatat dalam satuan kilometer. Interpretasi dilakukan menggunakan tabel berikut untuk konversi.

Tabel 1. Norma Skor Mentah Tes Jalan/ Lari 12 Menit karyawan Tenaga Kerja dan Masyarakat untuk laki-laki Usia 20-59 tahun

Kategori	Usia (Tahun)			
	20-29	30-39	40-49	50-59
Istimewa	> 2, 65	> 2,53	> 2,48	> 2,33
Baik	2,41-2,64	2,35-2,51	2,25-2,46	2,10-2,32
Cukup	2,12-2,40	2,11-2,34	2,01-2,24	1,88-2,09
Kurang	1,96-2,11	1,90-2,10	1,83-2,00	1,66-1,87
Sangat Kurang	< 1,95	< 1,89	< 1,82	< 1,65

Sumber: Kenneth H, Cooper, M.D. The Aerobics Program For Total Well Being. New York: Bantam Books, 1982:141

Tabel 2. Norma Skor Mentah Tes jalan/ lari 12 Menit Karyawan, Tenaga Kerja dan Masyarakat untuk perempuan Usia 20-59 tahun

Kategori	Usia (Tahun)			
	20-29	30-39	40-49	50-59
Istimewa	> 2,17	> 2,09	> 2,01	> 1,91
Baik	1,97-2,16	1,91-2,08	1,80-2,00	1,71-1,90
Cukup	1,80-1,96	1,71-1,90	1,59-1,79	1,51-1,70
Kurang	1,59-1,79	1,53-1,70	1,42-1,59	1,35-1,50
Sangat Kurang	< 1,59	< 1,52	< 1,41	< 1,34

Sumber: Kenneth H, Cooper, M.D. The Aerobics Program For Total Well Being. New York: Bantam Books, 1982:141

3. Tes lari 2,4 km

Tes ini bertujuan untuk mengukur daya tahan paru jantung-paru dengan menggunakan fasilitas dan alat berikut:

a. lintasan datar untuk lari,

b. alat pencatat waktu dan

c. pengukur jarak

Petugas memberikan aba-aba lalu peserta tes berjalan/lari sejauh 2.4 km. Interpretasi dilakukan menggunakan tabel berikut untuk konversi.

Tabel 3. Norma Skor Mentah Tes Jalan/ Lari 2,4 Km karyawan Tenaga Kerja dan Masyarakat untuk laki-laki Usia 20-59 tahun

Kategori	Usia (Tahun)			
	20-29	30-39	40-49	50-59
Istimewa	> 9:45 >	> 10:00	> 10:30	> 11:00
Baik	10:46-12:00	11:01-12:30	11:31-13:00	12:31-14;30
Cukup	12:46-12:00	12:31-14:45	13:01-15:35	14:31-17:00
Kurang	14:01-16:00	14:44-16:30	15:36-17:30	17:01-19:00
Sangat Kurang	< 16:01	< 16:31	< 17:31	< 19:01

Sumber: Kenneth H, Cooper, M.D. The Aerobics Program For Total Well Being. New York: Bantam Books, 1982:141

Tabel 4 Norma Skor Mentah Tes jalan/ lari 12 Menit Karyawan, Tenaga Kerja dan Masyarakat untuk perempuan Usia 20-59 tahun

Kategori	Usia (Tahun)			
	20-29	30-39	40-49	50-59
Istimewa	> 12:30	> 13:00	> 13:45	> 14:30
Baik	13:31-15:54	14:31-16:30	15:56-17:30	16:31-19:00
Cukup	15:55-18:30	16:31-19:00	17:31-19:30	19:01-20:00
Kurang	18:31-19:00	19:01-19:30	19:31-20:00	20:01-20:30
Sangat Kurang	< 19:01	< 19:31	< 20:01	< 20:01

Sumber: Kenneth H, Cooper, M.D. The Aerobics Program For Total Well Being. New York: Bantam Books, 1982:141

4. Tes Lari 15 Menit (*Balke*)

Tujuan tes ini untuk mengukur kapasitas VO2 max seseorang dengan menggunakan fasilitas dan alat berikut:

a. lintasan datar untuk lari,

b. alat pencatat waktu dan

c. pengukur jarak

d. bendera *start*

Petugas memberikan aba-aba lalu peserta tes berjalan/lari sejauh mungkin dalam 15 menit. Interpretasi dilakukan menggunakan rumus berikut.

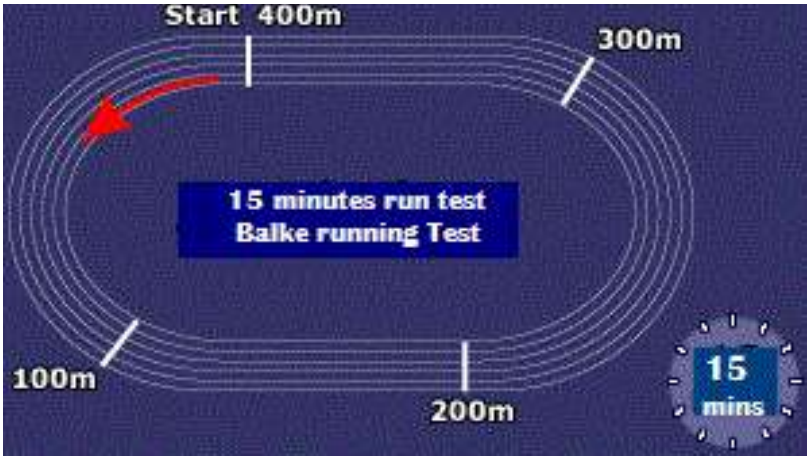
$$VO2\ max = \left(\frac{X\ meter}{15} - 133 \right) X\ 0{,}172 + 33{,}3$$

Keterangan:

VO2 max = kapasitas aerobik (ml/kg.BB/menit)

X = jarak yang ditempuh dalam meter

15 = waktu selama 15 menit



Gambar 1. Lintasan lari pada tes balke atau tes lari 15 menit
Sumber: http://sportsscience7.blogspot.com/2014/03/mengukur-vo2max-dengan-metode-balke.html

Tabel 5. Klasifikasi Kebugaran Jasmani berdasar VO2 max pada atlit pria

Kategori	Usia (Tahun)		
	20-29	30-39	40-49
Tinggi	53 ke atas	49 ke atas	45 ke atas
Bagus	43-52	39-48	36-44
Cukup	34-42	31-38	27-35
Sedang	25-33	23-30	20-26
Rendah	24 ke bawah	22 ke bawah	19 ke bawah

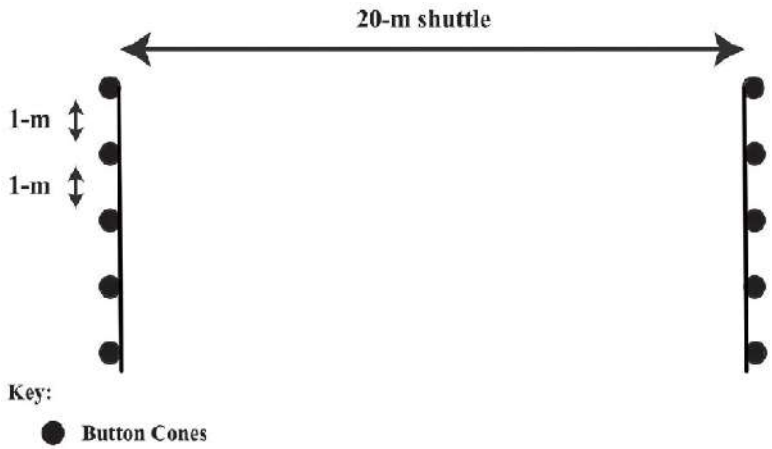
Tabel 6. Klasifikasi Kebugaran Jasmani berdasar VO2 max pada atlit wanita

Kategori	Usia (Tahun)		
	20-29	30-39	40-49
Tinggi	49 ke atas	45 ke atas	42 ke atas
Bagus	38-48	34-44	31-41
Cukup	31-37	28-33	24-30
Sedang	24-30	20-27	17-23
Rendah	23 ke bawah	19 ke bawah	16 ke bawah

5. Tes multi tahap

Tes ini juga bertujuan untuk mengukur tingkat efisiensi fungsi jantung dan paru-paru berdasarkan nilai maksimum ambilan oksigen. Alat yang dibutuhkan adalah:

a. lintasan datar untuk lari,
b. alat pencatat waktu dan
c. pengukur jarak
d. kaset (pita suara)



Gambar 2. Gambar lintasan tes multi tahap
Sumber: Saward dkk, 2020

Sebelum pelaksanaan tes, dilakukan pemberian tanda pada ujung jarak 20 meter dengan kerucut atau tanda lain. Setelah peserta melakukan pemanasan dan peregangan terutama di bagian otot-otot kaki, kemudian hidupkan pita suara. Jarak antara dua sinyal ”TUT” menandai suara interval 1 menit.

Beberapa petunjuk untuk peserta tes telah tersedia dalam kaset. Pita kaset mengeluarkan sinyal suara ”TUT” tunggal pada beberapa interval yang teratur. Peserta tes berusaha sampai ke ujung berlawanan bertepatan dengan saat sinyal ”TUT” yang pertama berbunyi. Lari terus dilakukan dengan kecepatan sama agar sampai ke ujung lintasan bertepatan dengan terdengarnya sinyal ”TUT” berikutnya. Setelah satu

menit, interval waktu diantara dua sinyal ”TUT” akan berkurang, sehingga lari harus semakin cepat.

Kecepatan lari pada menit pertama disebut tahap 1, kecepatan kedua disebut tahap 2 dan seterusnya. Setiap tahap dilakukan masing-masing selama 1 menit. Akhir setiap lari bolak-balik (balikan) ditandai dengan sinyal ”TUT” tiga kali berturut-turut. Peserta tes harus selalu menempatkan satu kaki pada atau tepat di belakang tanda garis start/finish pada akhir setiap kali lari. Apabila peserta tes telah mencapai salah satu batas lari sebelum sinyal ”TUT” berikutnya, peserta tes harus berbalik (dengan bertumpu pada sumbu putar kaki tersebut) dan menunggu isyarat bunyi ”TUT” kemudian melanjutkan lari dan menyesuaikan kecepatan lari pada tahap berikutnya. Lari terus dilanjutkan selama mungkin sampai tidak mampu lagi menyesuaikan dengan kecepatan yang telah diatur dalam pita rekaman suara.

Tes ini bersifat maksimal dan progresif karena kesulitannya akan meningkat bertahap, semakin mendekati akhir semakin sulit. Agar hasilnya cukup valid, peserta tes harus mengerahkan kerja maksimal sewaktu menjalani tes ini, dan oleh karena itu peserta tes harus berusaha mencapai tahap setinggi mungkin sebelum menghentikan tes.

Setelah melakukan tes, peserta melakukan gerakan-gerakan pendinginan dengan cara berjalan santai dan peregangan-peregangan otot. Jumlah terbanyak dari level dan balikan

sempurna yang berhasil diperoleh dicatat sebagai skor peserta tes

6. Tes Lari di atas *treadmill*

Tes ini mudah dilakukan. Peserta lari diatas treadmill dengan kecepatan dan dalam jangka waktu tertentu yang telah diatur oleh mesin. Tes ini juga bersifat progresif. Peserta diharapkan lari secara wajar mengikuti kecepatan mesin dan tidak berpegangan pada stang. Dari tes tersebut akan diperoleh skor terbaca pada monitor yang menunjukkan besarnya VO2 max.

Tabel 7. Tingkat kebugaran Jasmani berdasarkan VO2 max (ml/kg.BB/menit) untuk Pria

Kategori	**Usia (Tahun)**			
	20-29 Th	30-39 Th	40-49 Th	Di atas 50 Th
Sempurna	> 55	> 52	> 50	> 40
Sangat Baik	50-54	47-51	45-49	43-47
Baik	45-49	42-46	40-44	38-42
Sedang	40-44	37-41	53-39	33-37
Cukup	36-39	33-36	31-34	29-32
Kurang	31-35	28-32	26-30	24-28
Kurang Sekali	< 30	< 27	< 25	< 23

Tabel 8. Tingkat kebugaran Jasmani berdasarkan VO2 max (ml/kg.BB/menit) untuk wanita

Kategori	**Usia (Tahun)**			
	20-29 Th	30-39 Th	40-49 Th	Di atas 50 Th
Sempurna	> 49	> 45	> 43	> 40
Sangat Baik	44-48	40-44	38-42	36-39
Baik	39-43	39-39	34-37	32-35
Sedang	34-38	31-35	29-33	27-31
Cukup	30-33	27-30	25-28	23-26
Kurang	25-29	22-26	20-24	18-22
Kurang Sekali	< 24	< 21	< 19	< 17

BAB II
VO2 MAX DAN FAKTOR YANG MEMPENGARUHI

A. VO2 MAX

Volume oksigen maximal atau sering disingkat menjadi VO_2 max adalah volume maksimal O2 yang dapat diproses oleh tubuh pada saat melakukan kegiatan yang intensif, misalnya olahraga fisik. VO2max juga diartikan sebagai kapasitas maksimal tubuh dalam mengambil, mentranspor, dan menggunakan oksigen selama latihan (Gomez Cabrera dkk, 2008). VO2 max menunjukkan seberapa besar kecepatan pemakaian oksigen dalam metabolisme aerob maximum (Zoladz dkk, 2009).

Volume oksigen maksimal ini adalah suatu tingkatan kemampuan tubuh yang dinyatakan dalam liter per menit atau milliliter/menit/kg berat badan. Tinggi rendahnya kadar VO2 max seseorang berhubungan dengan kemampuan orang tersebut melakukan aktivitas. Artinya, semakin tinggi kadar VO2 max yang dimilikinya, maka tingkat aktivitas yang mampu dilakukannya juga semakin tinggi, sebaliknya tingkat kelelahannya semakin rendah (Morie dkk, 2010).

Kapasitas aerobik maksimal atau konsumsi oksigen maksimal atau VO2 max ini menjadi indikator dasar yang praktis dilakukan dalam menilai kebugaran jasmani seseorang. VO2 max adalah jumlah oksigen maksimum yang dapat

dikirim dari paru-paru ke otot dalam milimeter, atau dalam menit per kilogram berat badan. Seseorang yang memiliki stamina yang baik memiliki nilai VO2 max yang lebih tinggi, dapat melakukan latihan yang lebih berat, dan memiliki daya konsentrasi yang lebih tinggi dibandingkan dengan seseorang yang memiliki stamina yang buruk (Madina, 2007).

Kadar VO2 max berhubungan dengan kemampuan kerja otot seseorang. Semakin berat beban kerja seseorang, maka semakin tinggi juga konsumsi oksigennya. Jumlah otot yang terlibat untuk pendistribusian dan pemanfaatan oksigen yang dipasok dipengaruhi oleh massa otot itu sendiri. Semakin besar massa otot rangka yang mendapatkan beban kerja, maka akan semakin besar pula ambilan oksigen yang terjadi. Tingkat VO2 max menunjukkan kemampuan ekstraksi yang sangat mempengaruhi seberapa besar ambilan oksigen oleh jaringan sesuai. Kemampuan ekstraksi oksigen yang baik akan menghasilkan ambilan oksigen yang lebih banyak ke jaringan. Semakin tinggi kadar VO2 max seseorang, akan semakin lama otot menahan beban kerja. Hal ini mengindikasikan bahwa orang dengan kadar VO2 max tinggi lebih tidak cepat lelah dibanding orang dengan VO2 max yang lebih rendah (Ganong, 2002).

Kadar VO2 max juga menjadi indikator tingkat kesehatan dan daya tahan sistem organ kardiorespirasi, yakni jantung dan pembuluh darah, serta paru. Daya tahan jantung

dan paru menjadi salah satu unsur yang berpengaruh terhadap tingkat kebugaran jasmani dan kesehatan seseorang secara umum. Sehingga, peningkatan kebugaran jasmani juga menguntungkan bagi kesehatan jantung dan paru. Sistem ini juga bersifat fundamental bagi kesehatan seseorang (Ismayarti dkk, 2009). Dikarenakan VO2 max sangat dipengaruhi oleh kemampuan atau daya tahan sistem kardiorespirasi, sehingga selama ini VO2 max telah menjadi indikator yang mudah diperiksa untuk menilai tingkat kebugaran jasmani dan ketahanan aerobik (Astorin, 2000; Rodrigues, 2006)

Tidak hanya oleh sistem kardiorespirasi, VO2 max juga dipengaruhi oleh banyak mekanisme fisiologis lain yang terlibat. Termasuk fungsi mitokondria dalam sel tubuh. Beberapa hal lain yang berpengaruh yakni sebagai berikut (Ismaryati dkk, 2009):

1. Sistem organ jantung dan paru

   Seluruh sistem fisiologis organ-organ ini harus berfungsi dengan baik sehingga oksigen yang masuk ke paru dan diedarkan melalui pembuluh darah ke seluruh jaringan dapat diperoleh dalam jumlah maksimal
2. Pembuluh darah dan sel darah

   Proses penyampaian oksigen ke jaringan-jaringan oleh sel-sel darah merah harus normal, agar oksigen dapat diangkut secara maksimal ke seluruh jaringan
3. Jaringan-jaringan tubuh terutama otot

Jaringan harus memiliki kapasitas yang normal untuk dapat menerima dan menggunakan O2 yang telah diedarkan kepadanya, sehingga aktivitas fisik dapat dilakukan dengan baik tanpa kelelahan

Tapi, banyak faktor lain yang juga berpengaruh terhadap nilai VO2 max seseorang, misalnya ukuran tubuh dan massa otot. Sehingga untuk penyamaan, VO2 max dinyatakan sebagai jumlah maximum O2 dalam satuan ml yang dapat digunakan tubuh dalam satu menit perkilogram berat badan (ml/kg/menit) (Mackenzie, 2013).

Banyak penelitian telah membuktikan bahwa nilai VO2 max yang lebih tinggi ditemukan pada orang dengan kebugaran jasmani baik dan kelompok ini memiliki kemampuan melakukan aktifitas lebih kuat dibanding kelompok yang kurang bugar (Mackenzie, 2013). Kadar VO2 max yang tinggi dapat diusahakan dengan cara rutin melalukan latihan dengan frekuensi tiga hingga lima kali perminggu (Alfian,2016), dengan durasi setiap latihan selama tiga puluh menit (Indriyani, 2007). Selama latihan tersebut diupayakan agar intensitas detak jantung tetap berada pada rentang 65% hingga 85% dari detak jantung maksimum. Hal ini karena nilai VO2 max sangat dipengaruhi oleh jumlah *cardiac output*, daya tahan sistem respirasi dalam mendistribusikan O2 ke dalam darah, serta kemampuan otot dalam penggunaan oksigen dimana massa otot yang semakin banyak akan meningkatkan

penggunaan O2 yang semakin banyak pula dalam satuan ml/menit selama latihan dengan intensitas maksimal tubuh (Vander, 2001).

Departemen Kesehatan pada tahun 2003 melakukan survei pada kelompok usia kerja untuk mengetahui tingkat kebugaran jasmani mereka. Hasilnya menunjukkan sebesar 92,4% dari subjek penelitian tergolong dalam kategori kurang bugar. Penelitian lain yang dilakukan oleh Pradono terhadap warga Kebon Manggis, Jakarta Timur yang masuk dalam kelompok usia dewasa muda yakni dengan rentang usia 20-39 tahun hasilnya menunjukkan bahwa 50,2% dari subjek tergolong kategori sangat kurang bugar, 26,8% kurang bugar, 15% cukup bugar, dan hanya 7,7% yang tergolong memiliki kebugaran jasmani baik (Pradono, 1999).

Sebagai mana disebutkan di atas, bahwa kebugaran jasmani dan nilai VO2 max dapat ditingkatkan dengan melakukan latihan fisik secara teratur dalam durasi dan intensitas yang sesuai. Salah satunya adalah dengan latihan aerobik, yakni suatu jenis latihan yang membutuhkan oksigen dan menggunakan energi dari pembakaran oksigen. Latihan ini praktis dan mudah dilakukan. Contoh latihan aerobik misalnya lari, jalan, treadmill, bersepeda, dan berenang.

Olahraga aerobik berdampak terhadap daya tahan sistem kardiorespirasi, karena jenis olahraga ini melatih peningkatan ambilan oksigen, meningkatkan kapasitas darah mengangkut oksigen melalui peningkatan jumlah kapiler aktif dalam

pendistribusian darah pengangkut oksigen, menurunkan jumlah lemak dalam darah, meningkatkan enzim pembakar lemak, dan menurunkan denyut nadi menjadi lebih rendah saat istirahat maupun beraktifitas. Sebaliknya, jenis latihan anaerobik adalah latihan yang menggunakan energi dari pembakaran tanpa oksigen sehingga latihan ini menimbulkan debet oksigen. Contoh latihan anaerobik adalah lari cepat jarak pendek, latihan angkat beban dan bersepeda cepat (Hermina, 2004)

Penelitian oleh Nasrulloh dilakukan untuk mengamati hubungan olahraga aerobik dengan peningkatan nilai VO2 max seseorang. Hasilnya menunjukkan bahwa latihan aerobik teknik kombinasi dapat meningkatan kemampuan daya tahan kardiorespirasi (Nasrulloh, 2009). Penelitian lain mengamati pengaruh latihan aerobik terhadap perubahan VO2 max pemain sepak bola remaja yang berusia dalam rentang 12 hingga 14 tahun. Dimana hasilnya menunjukkan bahwa latihan aerobik rutin selama 12 minggu secara signifikan meningkatkan nilai VO2 max subjek penelitian (Magsalmina, 2007).

Di zaman sekarang ini, manusia cenderung memiliki tingkat kesibukan yang semakin besar, mobilitas yang semakin tinggi, dan penggunaan teknologi yang semakin canggih. Cara melakukan olahraga pun sudah berkembang. Olahraga gymnastic yang dilakukan di dalam ruangan tertutup dapat

dilakukan kapan saja dengan alat-alat yang lengkap. Sebelumnya, olahraga identik dilakukan saat pagi hari, namun saat ini malam haripun banyak orang yang melakukan olahraga. Hal ini penting dibahas karena terkait dengan faktor jam biologis tubuh dimana malam hari merupakan waktu istirahatnya tubuh. Secara fisiologis diketahui bahwa kadar hemoglobin lebih rendah 1 gr% saat malam dibandingkan pagi hari, padahal hemoglobin ini yang bekerja sebagai pengikat oksigen untuk diedarkan ke jaringan tubuh (Gibson, 2005).

Selain itu, faktor perbedaan kondisi lingkungan siang dan malam juga berpengaruh terhadap kapasitas fisik dalam berolahraga. Tekanan oksigen lingkungan dan tingkat keasaman darah dalam tubuh cenderung lebih tinggi saat pagi hari, sedangkan pada malam hari kondisi tekanan oksigen lingkungan dan tingkat keasaman darah lebih rendah. Hal ini menyebabkan kemampuan hemoglobin mengikat oksigen lebih baik di pagi hari dibanding malam hari (Ganong, 2003).

Kelembaban udara di daerah permukaan lebih rendah saat malam hari. Proses kondensasi atau pengembunan dengan memanfaatkan uap air yang berasal dari udara juga terjadi pada malam hari, sehingga kandungan uap air di udara dekat permukaan tersebut akan berkurang akibatnya tekanan oksigen akan menurun. Kekuatan aerobik maksimal seseorang juga turun di malam hari karena terjadinya penurunan oksigen maksimal yang diakibatkan oleh paparan suhu malam yang cukup dingin sehingga mengurangi suhu inti tubuh negatif.

Dapat disimpulkan bahwa olahraga dengan jenis dan tempat yang sama akan berbeda hasil ketahanan aerobiknya antara yang dilakukan pagi dan malam hari. Hal ini disebabkan oleh faktor internal tubuh yakni perbedaan kemampuan dan kadar hemoglobin pengikat oksigen, dan faktor eksternal berupa perbedaan suhu udara dan kelembaban lingkungan.

B. Faktor-Faktor yang Mempengaruhi VO2 Max

1. Usia

Puncak ketahanan kardiorespirasi dan massa otot seseorang adalah pada rentang usia 18-25 tahun pada laki-laki (Arum dkk, 2014). Kemudian, ketahanan itu akan mulai menurun setelah usia 30 tahun karena faktor degenerative akibat pertambahan usia. Dan seseorang pada usia tersebut cenderung lebih memilih untuk banyak bekerja dan justru mengurangi beban fisik serta kegiatan olahraganya (Cengiz, 2008; Hodges, 2007). Akibatnya setelah usia puncak itu kemampuan aerobik dan VO2 max akan turun karena berkurangnya kontraksi dan massa otot jantung sehingga isi sekuncup jantung maksimal dan denyut jantung maksimal juga menurun.

Penurunan VO2 max ini terjadi sebesar 1.2% per tahun pada laki-laki atau sekitar 0.46 ml/kg/menit, dan penurunan lebih besar pada perempuan yakni 1.7% per tahun atau sekitar 0.54 ml/kg/menit (Mackenzie, 2013; Astorino, 2000; Huldani,

2010; Guyton, 2008). Karena pada saat usia lanjut, daya tahan fisik dalam melakukan latihan akan menurun akibat dari penurunan kekuatan otot dan energi, sehingga seseorang menjadi lebih mudah lelah (Firman, 2016; Hasiolan, 2017), maka seharusnya kebugaran jasmani dilatih dan ditingkatkan dengan latihan fisik sejak usia muda.

Penulis dkk. telah melakukan penelitian terhadap masing-masing 30 orang pada kelompok pria dan wanita sehat yang berusia antara 26-65 tahun. Rentang usia tersebut dikelompokkan menjadi dua, yakni kelompok dewasa muda berusia 26-45 tahun dan kelompok dewasa tua berusia 46-65 tahun. Seluruh responden diminta untuk jalan kaki 5-10 menit sebagai latihan pemanasan dan dilanjutkan dengan lari sejauh 1.6 km menggunakan metode *Rockport*. Nilai VO2 max responden diperoleh dengan cara mencocokkan waktu yang diperlukan untuk menyelesaikan lintasan lari tersebut ke tabel VO2 max yang sudah disiapkan. Hasilnya menunjukkan hasil yang sesuai dengan hipotesis bahwa terdapat perbedaan yang signifikan antara VO2 max kelompok dewasa muda dan lansia (Huldani dkk, 2020).

Penelitian serupa terhadap atlet pemain sepakbola juga menunjukkan hasil yang sama, dimana atlet dewasa muda berusia 18-35 tahun memiliki nilai kebugaran 42 kali dibanding kelompok atlet berusia >45 tahun (Firman, 2016). Meskipun sebenarnya banyak faktor fisiologis lain yang memengaruhi kebugaran seseorang, misalnya ketahanan

respirasi dan kardiovaskular yang menurun seiring bertambahnya usia sehingga nilai VO2 max juga mengalami penurunan (Retnosari, 2016; Woo, 2016; Firman, 2016).

Penelitian lain dilakukan kepada 60 orang subjek yang merupakan peserta ibadah haji. Subjek dibagi menjadi 2 kelompok berdasarkan usia, yakni dewasa muda dan usia lanjut. Hasilnya menunjukkan terdapat perbedaan yang signifikan antara VO2 max calon jemaah haji pada kelompok dewasa dan lansia. Usia dewasa muda lebih bugar daripada usia lansia dilihat dari nilai VO2 max kelompok dewasa muda lebih tinggi daripada kelompok lansia.

Sama dengan penelitian Firman pada atlet sepak bola kabupaten Nganjuk yang menyatakan bahwa VO2 max memiliki hubungan yang kuat dengan usia. Studi Word menggunakan uji Spearman dengan kekuatan hubungan sebesar 0,732. Hasil analisis juga menyebutkan bahwa risiko kebugaran jasmani atlet berusia 18-35 tahun memiliki peluang 42 kali lebih bugar dibandingkan dengan atlet berusia di atas 45 tahun (Retnosari dkk, 2016). Selain itu, perbedaan hasil pengukuran VO2 max dapat disebabkan oleh banyak faktor fisiologis. Karena jantung paru-paru berbeda antara orang dewasa dan orang tua. Calon jemaah haji usia di atas 46 tahun mengalami penurunan VO2 max. Penurunan ini terjadi karena paru-paru, jantung, dan pembuluh darah mulai menurun fungsinya (Putra dkk, 2020).

Pada usia remaja akhir terjadi masa transisi. Kebiasaan dan pola hidup yang terbentuk saat masa tersebut akan berdampak pada kehidupan saat dewasa, termasuk kebiasaan olahraga dan pola hidup sehat. Remaja yang terbiasa melakukan aktivitas fisik dengan teratur akan lebih bugar saat dewasa karena aliran oksigen dan peredaran darah lebih lancar dan risiko morbiditas serta mortalitas akibat penyakit kronis menurun, misalnya obesitas, penyakit sistem kardiovaskular, bahkan keganasan (Mikaelson dkk, 2019; Mize, 2017; Herman dkk, 2009; Gleeson, 2013; Hallal dkk, 2012).

2. **Jenis kelamin**

Secara fisiologis, tubuh wanita dan pria berbeda. Pada tubuh perempuan lebih banyak komposisi lemak dibandingkan otot, sedangkan pada laki-laki lebih banyak otot. Hal ini menyebabkan pria memiliki VO2 max yang lebih besar (Delany, 2013). Metabolisme lebih banyak terjadi pada otot dan jaringan lain yang aktif, sehingga metabolism yang terjadi pada laki-laki lebih tinggi (Mcmurray et al, 2014). Jenis kelamin, tinggi badan, dan berat badan juga mempengaruhi VO2 max (Astorin, 2000; Huldani, 2010; Guyton, 2008).

Penulis dkk telah melakukan penelitian terhadap masing-masing 30 orang pada kelompok pria dan wanita sehat yang berusia antara 26-65 tahun. Seluruh responden diminta untuk jalan kaki 5-10 menit sebagai latihan pemanasan dan dilanjutkan dengan lari sejauh 1.6 km menggunakan metode

Rockport. Nilai VO2 max responden diperoleh dengan cara mencocokkan waktu yang diperlukan untuk menyelesaikan lintasan lari tersebut ke tabel VO2 max yang sudah disiapkan. Hasilnya menunjukkan hasil yang sesuai dengan hipotesis bahwa terdapat perbedaan yang signifikan antara VO2 max kelompok wanita dan pria. Pada kelompok pria, 64.3% tergolong kategori bugar, sedangkan pada wanita hanya 37.5% yang tergolong bugar (Huldani dkk, 2020).

3. Jenis latihan

VO2 max memengaruhi kemampuan jaringan untuk mengambil oksigen, sehingga kemampuan setiap orang berbeda-beda. VO2 max yang tinggi menghasilkan ketahanan otot yang lebih baik, ditandai dengan otot lebih tidak mudah lelah. Sebaliknya, orang dengan nilai VO2 max rendah akan lebih mudah lelah (Ganong, 2002). Oleh karena itu, pada atlet nilai VO2 max yang tinggi sangat menguntungkan.

Untuk meningkatkan nilai VO2 max secara efektif, cara yang dapat dilakukan adalah dengan latihan fisik menggunakan beban yang cukup besar pada sistem kardiovaskular untuk menghasilkan peningkatan volume sekuncup dan *cardiac output*, sehingga suplai oksigen ke otot juga lebih besar. Dengan demikian seseorang dapat melakukan aktifitas olahraga dengan durasi yang lebih lama dan konsumsi oksigen maksimal yang lebih besar (Pratiwi dkk, 2012;

Ismaryati dkk, 2009). Semakin berat beban latihan yang dilakukan terhadap sistem kardiovaskuler, semakin tinggi pula konsumsi oksigen oleh jaringan. Besarnya konsumsi oksigen ini ditentukan oleh massa otot yang mempengaruhi kemampuan otot dalam menggunakan oksigen. Semakin besar massa otot rangka yang diberikan beban kerja, semakin besar pula ambilan oksigen oleh jaringan yang terlibat.

Latihan fisik memiliki 4 komponen dasar yaitu latihan jantung dan paru (kardiorespirasi), kekuatan otot, fleksibilitas dan komposisi tubuh.1 Salah satu cara latihan fisik adalah dengan latihan aerobik yang terbukti efektif memperbaiki kemampuan kerja jantung dan meningkatkan nilai VO2 max. Ada banyak pilihan metode latihan aerobik yang dapat dilakukan, misalnya latihan sirkuit, latihan kontinyu, dan latihan interval. Latihan lain misalnya permainan bola basket yang membuat atletnya bergerak aktif pada seluruh bagian tubuh sehingga terbentuk pengaturan napas yang baik dan lebih banyak konsumsi energi untuk metabolisme tubuh (Rozi, 2020; Aschendorf dkk, 2019; Oliver 2009)

Penelitian oleh penulis dkk terhadap pemain basket menunjukkan nilai VO2 max kelompok pemain basket lebih tinggi daripada kelompok bukan pemain basket. Hasil ini serupa dengan penelitian Anggi dkk yang menjelaskan bahwa terdapat perbedaan skor VO2 max pada siswa laki-laki usia 16-17 tahun setelah melakukan latihan fisik selama 6 minggu dengan sebelum latihan fisik. Stamina, pola istirahat, dan masa

pemulihan setiap individu pemain merupakan aspek yang mempengaruhi hasil kebugaran jasmani yang diperoleh. Berdasarkan hal-hal tersebut, aspek yang penting adalah kondisi fisik pemain yang optimal. Kondisi fisik pemain sangat memeengaruhi aktivitas dalam latihan, sehingga mempengaruhi peningkatan daya tahan (Rahman dkk, 2020).

Rahman dalam penelitiannya juga menjelaskan bahwa terdapat perbedaan signifikan tingkat VO2 max dan kebugaran jasmani anggota tim pelari yang rutin melakukan senam satu hingga dua kali seminggu dibandingkan kelompok yang tidak rutin berlatih (<1-2 kali seminggu) (Rahman dkk, 2020). Hasil penelitian ini juga didukung oleh penelitian Hatle yang dilakukan terhadap 21 siswa dengan usia rata-rata 23 tahun, memiliki BMI normal, tidak merokok, dan sehat secara fisik. Subyek penelitian dibagi menjadi 2 kelompok perlakuan yaitu kelompok dengan latihan intensitas sedang dan latihan intensitas tinggi. Kemudian sampel diberi perlakuan latihan aerobik 24 sesi yang dilakukan dalam kurun waktu 8 minggu. Kelompok yang diberikan pelatihan intensitas sedang mengalami peningkatan VO2 max selama masa pelatihan sampai dengan masa pelatihan berakhir dengan peningkatan VO2 max 10,7% secara progresif (Hatle dkk, 2014).

Penelitian lain yang dilakukan penulis dkk adalah terhadap 15 siswa SMAN 1 Banjarbaru yang merupakan atlet bola basket dan 15 siswa lainnya yang bukan atlet. Seluruh

responden melakukan latihan *multistage fitness test* pada hari pertama, lalu istirahat pada hari kedua, dan pada hari ketiga dilakukan penghitungan nilai jantung maksimal dengan formula Tanaka. Responden dipasangi alat pulse oksimetri dan melakukan lari berkelompok hingga denyut nadi mencapai 70-90% sebagai latihan pemanasan. Setelah mencapai target responden tetap lanjut berlari selama 12 menit sebagai latihan aerobik intensitas sedang. Setelah selesai lari, dilakukan pemeriksaan kadar VO2 max. Hasilnya menunjukkan bahwa nilai VO2 max siswa remaja yang terlatih bola basket lebih tinggi dibandingkan dengan remaja yang tidak terlatih. Artinya kelompok tersebut lebih bugar (Huldani dkk, 2021).

Ada 2 faktor yang memengaruhi nilai VO2 max, yakni faktor pusat dan perifer (MacPherson dkk, 2011). Faktor sentral meliputi peningkatan stroke volume dan sedikit peningkatan denyut jantung maksimal. Kedua hal tersebut meningkatkan nilai VO2 max. Secara perifer, peningkatan perbedaan oksigen arteri-vena, transportasi oksigen ke serat otot aktif, adaptasi enzim lokal, dan kepadatan mitokondria, dapat meningkatkan nilai VO2 max. Peningkatan perifer dalam VO2 max diamati dalam pelatihan interval sprint (Buchan dkk, 2011).

Latihan fisik tiga kali seminggu selama tujuh minggu dengan intensitas sedang dapat meningkatkan nilai VO2 max dibandingkan dengan mereka yang tidak berolahraga pada remaja (Buchan dkk, 2011). Hal ini kemungkinan disebabkan

oleh pengaruh latihan fisik intensitas sedang terhadap curah jantung, dimana latihan fisik mengakibatkan peningkatan curah jantung akibat peningkatan volume sekuncup (Gleeson dkk, 2013).

Penelitian Ranto menyebutkan bahwa latihan fisik yang efektif yaitu latihan fisik yang mampu meningkatkan nilai VO2 max. Namun pada calon jemaah haji lanjut usia, rutinitas dan aktivitas latihan fisik mengalami penurunan, sehingga resistensi VO2 max juga menurun. Keadaan olahraga pada lansia sebenarnya sudah terbentuk sejak dewasa muda, sehingga jika keadaan olahraga pada masa muda sudah tinggi maka kemungkinan akan berdampak pada kondisi kebugaran diusia lanjut. Selain itu, kelelahan juga menjadi salah satu penyebab menurunnya daya tahan fisik dalam melakukan aktivitas yang akan mempengaruhi VO2 max. Semakin tua usia seseorang maka kebutuhan energi juga semakin berkurang, dan terjadi penurunan kekuatan otot yang menyebabkan semakin cepat lelah (Firman, 2015; Sihombing dkk, 2018).

4. **Fungsi respirasi dan kardiovaskular**

Pada saat melakukan aktifitas fisik, terjadi peningkatan kebutuhan O2 pada otot yang sedang bekerja. Kebutuhan O2 ini didapat dari ventilasi dan pertukaran O2 dalam paru. Ventilasi merupakan proses mekanik sistem respirasi untuk

memasukkan dan mengeluarkan udara ke dan dari dalam paru. Proses ini berlanjut dengan pertukaran O2 dalam alveoli paru dengan cara difusi. O2 yang terdifusi masuk ke dalam kapiler paru untuk selanjutnya diedarkan melalui pembuluh darah ke seluruh tubuh. Untuk dapat memenuhi kebutuhan O2 yang adekuat dibutuhkan paru yang berfungsi dengan baik, termasuk juga kapiler dan pembuluh pulmonal.

Pada seorang atlet yang terlatih dengan baik, konsumsi O2 dan ventilasi paru total meningkat sekitar 20 kali pada saat ia melakukan latihan dengan intensitas maximal (Fox, 2003). Dalam fungsi paru juga dikenal istilah A-V O2 diff. Selama aktifitas fisik, A-V O2 akan meningkat karena O2 darah lebih banyak dilepas ke otot yang sedang bekerja, akibatnya O2 darah vena berkurang. Hal ini menyebabkan pengiriman O2 ke jaringan naik hingga tiga kali lipat daripada kondisi biasa. Peningkatan A-V O2 diff terjadi serentak dengan peningkatan *cardiac output* dan pertukaran udara sebagai respon terhadap olahraga yang berat (Vander, 2001).

Respon kardiovaskular yang paling utama terhadap aktivitas fisik adalah peningkatan *cardiac output*. Peningkatan ini disebabkan oleh peningkatan isi sekuncup jantung maupun heart rate yang dapat mencapai sekitar 95% dari tingkat maximalnya (Uliyandari A, 2009). Pada usia 18-22 tahun tekanan darah normal apabila didapatkan sistole 120-140 mmHg dan tekanan darah diastol 80-100 mmHg (Joyner M.J, 2009). Denyut nadi normal 60-100 kali per menit (Hermawan,

2015). Pemakaian O2 oleh tubuh tidak dapat lebih dari kecepatan sistem kardiovaskular menghantarkan oksigen ke jaringan, maka dapat dikatakan bahwa sistem kardiovaskuler dapat membatasi nilai VO2max (Uliyandari A, 2009). Ketahanan sistem kardiovaskuler dan sistem respirasi akan mulai menurun setelah usia 30 tahun karena faktor degeneratif akibat pertambahan usia.

5. Hemoglobin

Saat beraktifitas, organ penting pernafasan yaitu paru-paru perlu mendapatkan O2 yang segar untuk memenuhi metabolisme dalam tubuh yang meningkat. Melalui fungsi ini maka O2 di bawa paru-paru ke seluruh jaringan sel darah dalam tubuh lalu dibawa kembali kandungan karbondioksida (CO2) yang tinggi dari seluruh sel ke paru-paru untuk di keluarkan dari tubuh. Komponen penting yang terlibat dalam proses ini adalah senyawa yang membawa O2 yaitu hemoglobin (Hb) yang berada di dalam sel darah merah, sehingga bila kadar Hb rendah, O2 yang di bawa sel darah merah juga sedikit (Nisar dkk, 2013).

Di dalam darah O2 berikatan dengan Hb, maka kadar O2 dalam darah juga ditentukan oleh kadar Hb yang tersedia. Jika kadar Hb berada di bawah normal, misalnya pada anemia, maka jumlah O2 dalam darah juga lebih rendah. Sebaliknya, bila kadar Hb lebih tinggi dari normal, seperti pada keadaan

polisitemia, maka kadar O2 dalam darah akan meningkat. Hal ini juga bisa terjadi sebagai respon adaptasi pada orang-orang yang hidup di tempat yang tinggi. Kadar Hb juga dipengaruhi oleh hormon androgen melalui peningkatan pembentukan sel darah merah. (Grossmann dkk, 2012).

Adanya perbedaan tingkat konsentrasi hemoglobin antara pria dan wanita juga menjadi penyebab nilai VO2 max berbeda antara kedua kelompok tersebut. Laki-laki memiliki kadar Hb sekitar 1-2 gr per 100 ml lebih tinggi dibanding wanita. Kadar hemoglobin berkisar antara 13.5-18.0 g% pada pria dan lebih rendah yakni 11.5-16.5 g% pada wanita. Hemoglobin berfungsi mengikat oksigen yang dibawa dalam sirkulasi tubuh ke seluruh organ untuk digunakan dalam proses pembakaran energi. Pada pria konsentrasinya lebih tinggi daripada wanita, sehingga pria dapat menghasilkan energi lebih optimal (Katch dkk, 2011; Ferriyanto, 2010; Hoeger, 2010; Yunus, 2011).

6. Faktor perancu lainnya

a. Perokok

Seseorang dikatakan sebagai perokok aktif jika yang telah menghisap 100 batang rokok selama hidupnya dan masih aktif merokok (CDC, 2003). VO2 max pada seorang perokok, baik aktif maupun pasif, akan mengalami peningkatan, hal ini karena merokok akan menyebabkan terjadi perubahan fisiologis baik

akut maupun kronik. Perubahan akut yang terjadi berupa peningkatan mendadak kebutuhan O2 sedangkan perubahan kronik yang terjadi adalah peningkatan level tiroksin (Metsios, et al., 2008).

b. Kafein

Kafein dapat menimbulkan efek ergogenic yang mampu meningkatkan tekanan darah dan menurunkan aliran darah karena bersifat sebagai β2-agonis. Aktivasi reseptor β2 adrenergik oleh kafein menyebabkan aktivitas enzim adenylate siklase serta peningkatan produksi cAMP (Liu et al, 2015).

c. Indek Massa Tubuh (IMT)

Indek Massa Tubuh (IMT) atau *Body Mass Indexs* (BMI) merupakan cara sederhana untuk memantau status gizi seseorang, khususnya yang berkaitan dengan kekurangan dan kelebihan berat badan (obesitas). Berat badan yang kurang, dapat meningkatkan resiko penyakit infeksi, sedangkan berat badan yang berlebihan akan meningkatkan resiko penyakit degeneratif. Usia harapan hidup cenderung lebih panjang pada seseorang yang mampu mempertahankan berat badannya dalam rentang normal (Ristianingrum et al, 2010).

Penelitian membuktikan bahwa IMT berhubungan terbalik dengan nilai VO2max, artinya semakin tinggi

IMT seseorang, maka nilai VO2 maxnya lebih rendah, yang artinya tingkat kebugaran jasmaninya kurang (Budiarto RA, 2012).

d. Radikal O2 reaktif

Radikal O2 reaktif terbentuk selain secara alamiah melalui sistem biologis tubuh, juga dapat dipicu oleh dua faktor, yaitu faktor internal dan faktor eksternal.

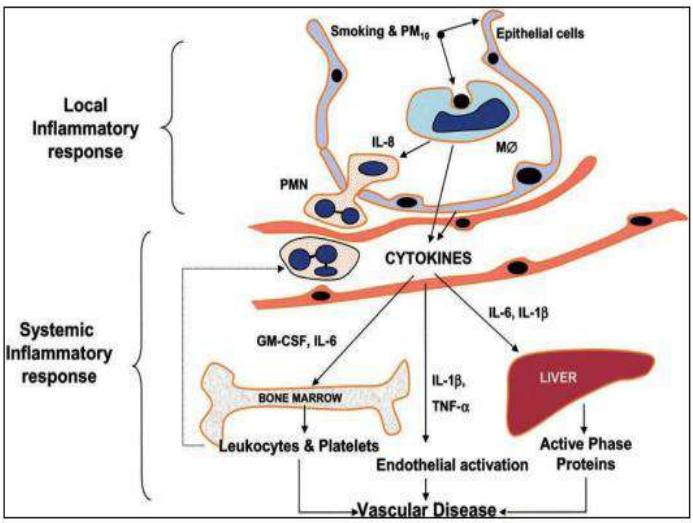
Faktor internal yang dimaksud ini meliputi setiap proses infeksi. Bila respon imun kurang baik saat terjadi infeksi, maka produksi radikal O2 reaktif yang berlebihan ini akan melampaui kapasitas penetralannya, dan akan diangkut sistem peredaran darah ke seluruh tubuh (Danusantoso, 2003). Kelebihan gizi juga merupakan faktor internal pemicu radikal O2 reaktif. Hal ini karena saat dimetabolisme, disamping energi juga akan dihasilkan radikal O2 reaktif (Ardhie, 2011).

Penyebab lain yang sering tidak disadari adalah latihan jasmani yang terlalu berat, dimana saat tubuh memerlukan sintesa ATP yang jauh lebih besar dari biasanya dan terjadi peningkatan produksi radikal O2 reaktif secara berlebihan. *Exercise induced-asthma* adalah contoh kasus komplikasi dimana terjadi serangan asma akut akibat penderita melakukan aktivitas fisik yang berat (Danusantoso, 2003). Contoh dari aktivitas fisik yang berat adalah berlari 1 mil, berenang 400 meter,

mendayung 2000 meter, lari maraton, dan lari cepat 800 meter (Joyner dkk, 2008).

Sedangkan faktor eksternal yang menyebabkannya misalnya polusi udara yang meningkatkan radikal O2 reaktif secara langsung, kemudian menimbulkan stres oksidatif pada paru. Polusi udara juga secara tidak langsung akan mengakibatkan sel-sel saluran pernapasan yang terpapar akan ikut menyintesis radikal O2 reaktif dengan berbagai mekanisme yang berbeda. Contoh dari polusi udara adalah polutan industri, emisi kendaraan bermotor dan asap rokok (Danusantoso, 2003).

Di samping pengaruh langsung seperti di atas, asap rokok dan asap dari pembakaran bahan-bahan organik mengandung Fe serta. Fe adalah stimulator yang kuat untuk pembentukan radikal O2 reaktif (Danusantoso, 2003). Paparan sinar UV terutama sinar UVB dapat memicu produksi anion superoksida melalui aktivasi *nicotinamide adenin dinucleotide phosphate* (NADPH) oksidase dan rantai reaksi pernafasan di mitokondria. Sinar UVB dapat menyebabkan kerusakan kulit secara langsung, sedangkan sinar UVA akan menimbulkan kerusakan melalui pembentukan radikal O2 reaktif (Ardhie, 2011).



Gambar 3. Respon inflamasi akibat asap rokok dan partikel asing lainnya
Sumber: Van Eeden dkk, 2005

Faktor eksternal pada peningkatan radikal O2 reaktif lainnya adalah alkohol. Dalam proses metabolismenya, alkohol diubah menjadi asetaldehid oleh enzim alkohol dehidrogenase. Asetaldehid memiliki tingkat toksisitas sepuluh kali lebih tinggi dibandingkan dengan alkohol. Akumulasi asetaldehid akan menurunkan antioksidan dan meningkatkan radikal O2 reaktif.

Pelepasan radikal O2 yang reaktif memiliki efek perusak terhadap sel endotel yang menginaktifkan *nitric oxide* (NO). Akibatnya aktifitas NO sebagai penghambat adhesi trombosit dan monosit di endotel serta efek anti proliferatif dan vasodilatasi pada otot pembuluh darah

menjadi hilang. Penghambatan vasodilatasi mendorong terjadinya spasme atau vasokontriksi pembuluh darah, sehingga menyebabkan peningkatan resistensi pembuluh darah (Silbernagel S, lang F, 2007).

e. Afterload (*pressure work*)

Afterload adalah jumlah resistensi total yang harus dilawan saat ventrikel berkontraksi. Apabila afterload meningkat maka isi sekuncup dan *cardiac output* menurun, akibatnya terjadi refleks peningkatan resistensi vaskular sistemik melalui peningkatan simpatis dan katekolamin dalam sirkulasi tubuh, hal ini kemudian akan memperkecil *cardiac output*. Sebaliknya, *cardiac output* akan meningkat dengan berkurangnya *afterload*

BAB III
PENGARUH OLAHRAGA TERHADAP IMUNITAS

1. Leukosit

Tubuh manusia memiliki sistem pertahanan yang kompleks yang disebut sistem imun. Sistem ini memungkinkan tubuh untuk dapat bereaksi dengan cepat dan spesifik terhadap cedera, peradangan, atau infeksi. Salah satu komponen terpenting adalah leukosit. Oleh karena itu dapat dikatakan bahwa leukosit merupakan indikator status infamasi tubuh. Jumlah leukosit dipengaruhi oleh banyak hal seperti infeksi, peradangan, stres, dan cedera fisik yang dialami seseorang, baik dalam kondisi akut maupun kronis (Tenorio dkk, 2014).

Leukosit merupakan sel darah putih yang diproduksi oleh jaringan hemopoetik dan jaringan limpatik. Terdapat dua jenis leukosit, yakni leukosit bergranula (polimorfonuklear) yang diproduksi oleh jaringan hemopoetik dan leukosit tak bergranula (mononuklear) yang diproduksi oleh jaringan limpatik. Leukosit berfungsi dalam sistem pertahanan tubuh terhadap infeksi (Sutedjo, 2007).

Leukosit merupakan komponen utama kekebalan tubuh dalam sirkulasi, yang berfungsi menjaga tubuh dari berbagai infeksi. Jumlah leukosit sangat cepat berubah dalam sirkulasi darah. Dalam keadaan normal, jumlah total leukosit dalam

keadaan normal adalah sekitar 5.000-10.000 sel/mm3 dengan rata-rata 7.000 sel/mm^3. Sitasi lain menyebutkan leukosit paling sedikit dalam tubuh jumlahnya sekitar 4.000-11.000/mm3. Jumlah leukosit tersebut berubah-ubah dari waktu ke waktu, karena beberapa faktor pemicu. Faktor tersebut dapat berupa stimulus fisiologi ataupun patologis. Misalnya sesuai dengan jumlah benda asing yang dihadapi dalam batas-batas yang masih dapat ditoleransi tubuh tanpa menimbulkan gangguan fungsi (Sadikin, 2002).

Apabila sel tubuh mengalami suatu infeksi atau inflamasi, maka jumlah leukosit akan bertambah di area tersebut (Sherwood dll, 2012). Meskipun leukosit merupakan sel darah, tapi fungsi leukosit lebih banyak dilakukan di dalam jaringan. Leukosit hanya bersifat sementara mengikuti aliran darah ke seluruh tubuh. Apabila terjadi peradangan pada jaringan tubuh leukosit akan pindah menuju jaringan yang mengalami radang dengan cara menembus dinding kapiler (Kiswari,2014). Peningkatan jumlah leukosit yang melebih jumlah normal disebut dengan leukositosis, sedangkan leukosit dengan jumlah yang lebih rendah disebut dengan leukopenia. Pemeriksaan jumlah leukosit dapat menjadi sumber informasi untuk diagnostik dan prognosis serta gambaran adanya kerusakan organ dan pemulihan setelah latihan fisik yang berat (Sinaga dkk, 2017).

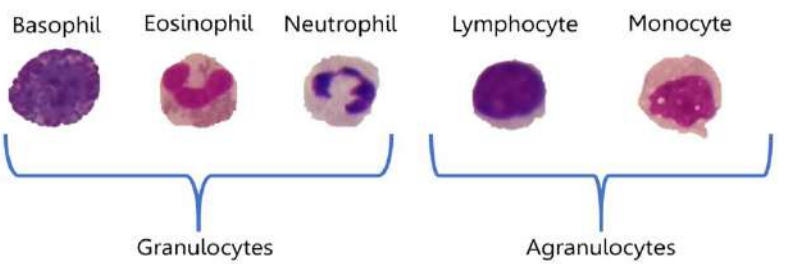
Leukosit terdiri dari 2 kategori yaitu granulosit dan agranulosit.

a. Granulosit

Ini merupakan sel darah putih yang di dalam sitoplasmanya terdapat granula-granula. Granula-granula ini mempunyai perbedaan kemampuan mengikat warna, misalnya pada eosinofil mempunyai granula berwarna merah terang, basofil berwarna biru, dan neutrofil berwarna ungu pucat.

b. Agranulosit

Ini merupakan bagian dari sel darah putih dimana mempunyai inti sel satu lobus dan sitoplasmanya tidak bergranula. Leukosit yang termasuk agranulosit adalah limfosit, dan monosit. Limfosit terdiri dari limfosit B yang membentuk imunitas humoral dan limfosit T yang membentuk imunitas selular. Limfosit B memproduksi antibodi jika terdapat antigen, sedangkan limfosit T langsung berhubungan dengan benda asing untuk difagosit.



Gambar 4. Klasifikasi leukosit
Sumber: Loddo dkk, 2021

Jumlah leukosit total dalam darah mengalami peningkatan selama dan segera setelah latihan fisik. Jumlah total leukosit meningkat selama dan segera setelah latihan, dan leukositosis terjadi pada 10 menit pertama pada latihan intensitas tinggi (Miyazaki dkk, 2001). Penelitian menunjukkan bahwa olahraga menyebabkan peningkatan signifikan dalam total leukosit dan limfosit pada 11 anak perempuan dibandingkan dengan 13 anak laki-laki yang diteliti. Artinya terdapat perbedaan imunologis pada kelompok usia dan jenis kelamin yang diteliti (Sand dkk, 2013).

Sensitifitas leukosit sangat bervariasi, tergantung dari intensitas dan durasi latihan yang dilakukan. Telah dilakukan penelitian untuk mengamati perbedaan jumlah leukosit pada kelompok yang melakukan latihan intensitas sedang dan kelompok yang melakukan latihan intensitas berat pada subjek 10 orang atlit judo melakukan latihan *treadmill* dengan intensitas ringan, sedang, dan berat selama 3 minggu. Hasilnya menunjukkan bahwa hanya pada latihan dengan intensitas sedang dan berat yang memberikan efek peningkatkan jumlah leukosit (Abdossaleh dkk, 2014).

Penelitian lain dilakukan di Brazil juga membuktikan adanya peningkatan jumlah leukosit yang lebih besar pada pria muda yang sehat secara fisik dan aktif setelah melakukan latihan intensitas tinggi dibandingkan pada kelompok subjek

yang hanya melakukan olahraga intensitas rendah dan tidak memiliki kebiasaan olahraga (Neves dkk, 2015).

Latihan kekuatan menginduksi leukositosis terutama neutrofil pada sirkulasi sistemik, kerusakan otot dan organ dalam serta penekanan imun (Suzuki, 2018). Penelitian oleh penulis dkk menunjukkan tidak ada perbedaan signifikan dalam jumlah leukosit antara kelompok bugar dan lelah, dengan rata-rata jumlah leukosit pada kelompok dengan VO2 max yang tergolong kategori bugar adalah 7,83 ribu/l dan 7,27 ribu/l pada kelompok kurang bugar (Huldani dkk, 2020). Secara statistik nilai ini tidak berbeda secara bermakna. Hasil penelitian ini selaras dengan penelitian Tenorio tahun 2014 tentang hubungan jumlah leukosit, status gizi, dan status kebugaran pada remaja yang justru menunjukkan hubungan negatif antara jumlah leukosit dengan status kebugaran remaja (Tenorio dkk, 2014).

Konsumsi oksigen dapat meningkat 100 hingga 200 kali lipat saat seseorang melakukan aktivitas fisik yang berat, hal ini terjadi karena meningkatnya metabolisme dalam tubuh. Peningkatan konsumsi oksigen selama aktivitas fisik menyebabkan peningkatan pembentukan spesies oksigen reaktif (ROS) (Clarkson dkk, 2000). Secara umum, 2-5% oksigen yang digunakan dalam proses metabolisme fosforilasi oksidatif mitokondria menjadi ion superoksida, yakni radikal bebas yang meningkat dengan aktivitas fisik yang berat (Chevion dkk, 2003).

Radikal bebas adalah senyawa atau atom yang memiliki elektron tidak berpasangan pada orbit terluarnya dan lebih reaktif dengan sel atau komponen seluler di dekatnya (10). Karena radikal bebas bersifat reaktif, maka dapat merusak komponen seluler seperti lipid, protein, dan DNA, menyebabkan mutasi, dan bersifat karsinogenik (Clarkson dkk, 2000). Tubuh memiliki mekanisme yang merespon bagian tubuh yang tidak berfungsi melalui proses homeostatis.

Proses ini dipengaruhi oleh faktor lokal dan sistemik (Schwartsi dkk, 1999). Salah satu faktor sistemik yang mempengaruhi proses ini adalah hormon glukokortikoid, yang terutama diwarisi oleh kortisol. Kortisol diproduksi oleh korteks adrenal dan diatur oleh hipotalamus melalui aksis hipotalamus-hipofisis-adrenal (HPA). HPA mengaktifkan respon stres, termasuk glukokortikoid yang mempengaruhi pergerakan dan fungsi sel darah putih, menyebabkan kematian sel darah putih, menekan sistem imun, dan memproduksi limfosit, eosinofil, monosit, dan basophil (Guyton dkk, 1997).

Latihan fisik juga bisa tidak menimbulkan perubahan pada kadar leukosit seseorang. Kadar glukokortikoid meningkat pada pagi hari dan menurun pada malam hari. Peningkatan kadar glukokortikoid pagi menimbulkan peningkatan ekspresi CXCR4 di sel CD8 + dan CD4 + yang menyebabkan remobilisasi sel CD8 + dan CD4+ dari darah ke

sumsum tulang, di mana banyak CXCL 12 diekspresikan, yang mengaktifkan CXCR4 oleh karena itu penurunan jumlah sel CD8+ dan CD4+.39 Fenomena ini kemungkinan menekan peningkatan jumlah leukosit sehingga tidak terjadi perbedaan yang signifikan antara jumlah leukosit kelompok pemain bola basket dan kelompok bukan pemain bola basket. Penelitian lain menemukan bahwa kadar kortisol pemain bola basket selama pelatihan pra-kompetisi berbanding terbalik dengan jumlah leukosit mereka (Albayrak dkk, 2013).

Kemungkinan lain yang menyebabkan perbedaan yang tidak signifikan dalam jumlah leukosit antara sampel pemain bola basket dan non-pemain bola basket setelah 12 menit latihan aerobik intensitas sedang adalah karena adanya migrasi leukosit. Interaksi ini akan menyebabkan leukosit terperangkap di dalam sel endotel, kemudian melekat dan bermigrasi ke tempat inflamasi dari lumen pembuluh darah (Nourshargh dkk, 2014; Huldani, Husairi, dkk, 2020; Huldani, Kaidah, dkk, 2020).

Proses migrasi ini kemungkinan akan menyebabkan akumulasi leukosit di pembuluh darah vena ekstremitas bawah karena penggunaan otot-otot ekstremitas bawah yang lebih dominan selama 12 menit latihan aerobik intensitas sedang. Sedangkan sampel darah yang digunakan untuk pemeriksaan kadar leukosit berasal dari vena cubiti, sehingga hal ini menyebabkan ketidaksesuaian antara lokasi pengambilan darah dengan lokasi inflamasi. Akibatnya darah yang diambil

tidak mencerminkan proses inflamasi yang sedang berlangsung. Ini menghasilkan perbedaan yang tidak signifikan antara jumlah leukosit pemain bola basket dan pemain non-basket **(**Huldani, Husairi, dkk 2021).

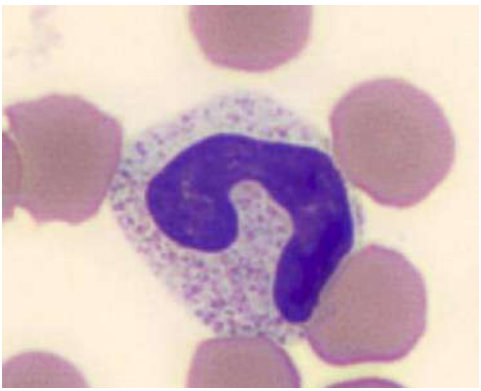
Secara khusus, dibawah diuraikan pengaruh latihan terhadap masing-masing jenis leukosit.

a. Neutrofil

Neutrofil berukuran sekitar 14 μm, granulanya berbentuk butiran halus tipis dengan sifat netral sehingga terjadi percampuran warna asam (eosin) dan warna basa (metilen biru), sedang pada granula menghasilkan warna ungu atau merah muda yang samar (Nugraha 2015). Neutrofil berfungsi sebagai garis pertahanan tubuh terhadap zat asing terutama terhadap bakteri. Bersifat fagosit dan dapat masuk ke dalam jaringan yang terinfeksi. Sirkulasi neutrofil dalam darah yaitu sekitar 10 jam dan dapat hidup selama 1-4 hari pada saat berada dalam jaringan ekstravaskuler (Kiswari,2014).

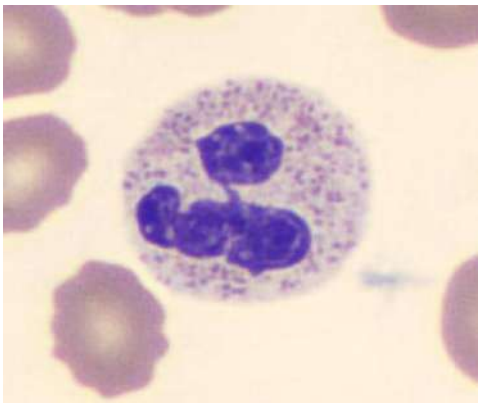
Neutrofil adalah jenis sel leukosit yang paling banyak yaitu sekitar 50-70% diantara sel leukosit yang lain. Ada dua macam netrofil yaitu neutrofil batang (stab) dan neutrofil segmen (polimorfonuklear) (Kiswari,2014). Perbedaan dari keduanya yaitu neutrofil batang merupakan bentuk muda dari neutrofil segmen sering disebut sebagai neutrofil tapal kuda karena mempunyai inti berbentuk seperti tapal kuda. Seiring

dengan proses pematangan, bentuk intinya akan bersegmen dan akan menjadi neutrofil segmen. Sel neutrofil mempunyai sitoplasma luas berwarna pink pucat dan granula halus berwarna ungu (Riswanto,2013).



Gambar 5. Neutrofil Batang Pewarnaan Giemsa
Sumber:
https://imagebank.hematology.org/image/60396/band-neutrophil?type=upload

Neutrofil segmen mempunyai granula sitoplasma yang tampak tipis (pucat), sering juga disebut neutrofil polimorfonuklear karena inti selnya terdiri atas 2-5 segmen (lobus) yang bentuknya bermacam-macam dan dihubungkan dengan benang kromatin. Jumlah neutrofil segmen yaitu sebanyak 3-6, dan bila lebih dari 6 jumlahnya maka disebut dengan neutrofil hipersegmen (Kiswari,2014).



Gambar 6. Neutrofil Segmen Pewarnaan Giemsa
Sumber: https://imagebank.hematology.org/image/60395/segmented-neutrophil?type=upload

Peningkatan jumlah neutrofil disebut netrofilia. Neutrofilia dapat terjadi karena respon fisiologik terhadap stres, misalnya karena olah raga, cuaca yang ekstrim, perdarahan atau hemolisis akut, melahirkan, dan stres emosi akut. Keadaan patologis yang menyebabkan netrofilia diantaranya infeksi akut, radang atau inflamasi, kerusakan jaringan, gangguan metabolik, apendisitis dan leukemia mielositik. Sedangkan penurunan jumlah neutrofil disebut dengan neutropenia, neutropenia ditemukan pada penyakit virus, hipersplenisme, leukemia, granolositosis, anemia, pengaruh obat-obatan (Riswanto, 2013)

Latihan intensif dapat menginduksi pro-sitokin atau anti inflamasi, yang terlihat jelas dengan peningkatan leukosit dalam sirkulasi. Namun, diketahui bahwa neutrofil merupakan salah satu sel imun pertama yang dilepaskan untuk merespon

trauma, terutama yang disebabkan oleh bakteri (Huldani dkk, 2019). Setelah berolahraga, konsentrasi neutrofil dalam darah akan meningkat hingga 100 kali lipat. Sedangkan sitokin dan kemokin yang diinduksi oleh aktivitas latihan antara lain interleukin 6, 8, 10 dan monotactic protein monosit (MCP)-1 (Goh dkk, 2018). Para peneliti sepakat bahwa atlet harus memeriksa juga memeriksa kadar beberapa komponen sitokin dalam proses pemeriksaan deteksi inflamasi kronis (Lee dkk, 2017).

Neutrofil berperan penting dalam kerusakan jaringan otot pada fase akut cedera otot, sedangkan monosit/makrofag mengatur regenerasi jaringan selanjutnya. Neutrofil dan monosit/makrofag mensekresi berbagai sitokin. Sel endotel, perisit, fibroblas, neutrofil, dan monosit/makrofag semuanya dapat berkontribusi pada ekspresi sitokin global dalam otot rangka (Peake dkk, 2015).

Neutrofil adalah sel fagosit yang berperan penting dalam respon imun bawaan. Sel-sel ini umumnya merupakan jenis sel pertama yang bekerja di tempat infeksi sehingga neutrofil terlibat dalam berbagai proses inflamasi, termasuk reaksi inflamasi pada jaringan otot, yang disebabkan oleh latihan fisik. Pada orang yang fit cenderung memiliki aktivitas fisik yang aktif, memungkinkan terjadinya mikrotrauma kronis pada jaringan otot sehingga menyebabkan penurunan jumlah neutrofil dalam sirkulasi. Hal ini dibuktikan dengan penelitian Harahap et al (2017) dan Marpaung et al (2015), yang

mengukur jumlah neutrofil sebelum dan sesudah latihan fisik pada atlet, dan menunjukkan hasil yang serupa.

Penulis dkk telah melakukan penelitian terhadap masing-masing 30 orang pada kelompok pria dan wanita sehat yang berusia antara 26-65 tahun. Setelah melakukan pemanasan 5-10 menit, responden melakukan lari sejauh 1.6 km dengan metode Rockport. Kemudian dilakukan pengkategorian kebugaran dengan melihat nilai VO2 max setelah latihan, lalu dilakukan pemeriksaan kadar neutrofil darah. Hasilnya menunjukkan kadar neutrofil dalam rentang normal pada seluruh responden. Namun ada perbedaan neutrofil secara signifikan antara kelompok responden yang bugar dan kelompok yang tidak bugar (Huldani dkk, 2020).

b. Limfosit

Limfosit adalah jenis leukosit kedua paling banyak setelah neutrofil (20- 40% dari total leukosit). Jumlah limfosit pada anak-anak relatif lebih banyak dibandingkan jumlah orang dewasa, dan jumlah limfosit ini akan meningkat bila terjadi infeksi virus. Berdasarkan fungsinya limfosit dibagi atas limfosit B dan limfosit T. Limfosit B matang pada sumsum tulang sedangkan limfosit T matang dalam timus. Keduanya tidak dapat dibedakan dalam pewarnaan Giemsa

karena memiliki morfologi yang sama dengan bentuk bulat dengan ukuran 12 μm.

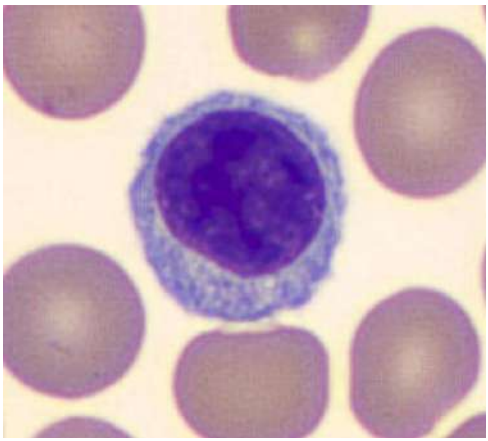
Sitoplasma sedikit karena semua bagian sel hampir ditutupi nukleus padat dan tidak bergranula (Nugraha, 2015). Limfosit B berasal dari sel stem di dalam sumsum tulang dan tumbuh menjadi sel plasma, yang menghasilkan antibodi. Limfosit T terbentuk jika sel stem dari sumsum tulang pindah ke kelenjar thymus yang akan mengalami pembelahan dan pematangan. Di dalam kelenjar thymus, limfosit T belajar membedakan mana benda asing dan mana bukan benda asing. Limfosit T dewasa meninggalkan kelenjar thymus dan masuk ke dalam pembuluh getah bening dan berfungsi sebagai bagian dari sistem pengawasan kekebalan (Farieh, 2008).

Berdasarkan ukuranya limfosit dibedakan menjadi beberapa jenis :

a. R*esting lymphocyte:* berukuran kecil (7-10 μm), inti selnya berbentuk bulat atau oval.
b. *Reactive ("activical") lymphocyte*: berukuran paling besar bila terjadi infeksi.
c. *Large granula lymphocyte*: berukuran sedang mengandung granula kasar azurofilik, berperan sebagai sel natural killer (NK) imunologi (Kiswari, 2015).

Ukuran sel limfosit beragam, ada yang seperti eritrosit dan ada yang sebesar netrofil. Limfosit dengan garis tengah 6-8 mikrometer dikenal sebagai limfosit kecil. Sitoplasma

limfosit bersifat basa lemah dan berwarna biru muda pada sediaan yang terpulas. Sitoplasma ini mengandung granul azurofilik. Inti selnya kebanyakan bulat atau terkadang mirip ginjal. Kromatin inti amat padat dan berwarna biru gelap. Sel ini juga relatif sedikit dan berwarna biru langit tanpa granul spesifik, namun pada beberapa sel terlihat granula azurofil yang jika pulasannya baik bewarna ungu kemerahan (Irianto, 2004).



Gambar 7. Limfosit Pewarnaan Giemsa
Sumber: https://imagebank.hematology.org/collection/60510

Limfosit memiliki kedudukan penting dalam sistem kekebalan tubuh, sehingga sel-sel ini tidak hanya terdapat di dalam darah, tetapi di dalam jaringan khusus yang disebut jaringan limfoid, yang diaktifkan ketika antigen atau stimulus lain muncul. Hasil penelitian ini sejalan dengan penelitian yang dilakukan oleh Yasirin et al (2014) tentang senam aerobik dan peningkatan limfosit CD4 (kekebalan) pada pasien

HIV. Hasil penelitian menunjukkan bahwa ada peningkatan yang signifikan pada limfosit CD4 setelah latihan aerobik pada pasien HIV. Hasil penelitian lainnya, oleh Harun dkk pada tahun 2017, mengenai perbandingan kadar interleukin-6 dan jumlah limfosit setelah senam aerobik ringan dan sedang pada remaja, juga menunjukkan hal yang sama (Harun, 2018).

Penulis dkk telah melakukan penelitian terhadap masing-masing 30 orang pada kelompok pria dan wanita sehat yang berusia antara 26-65 tahun. Setelah melakukan pemanasan 5-10 menit, responden melakukan lari sejauh 1.6 km dengan metode Rockport. Kemudian dilakukan pengkategorian kebugaran dengan melihat nilai VO2 max setelah latihan, lalu dilakukan pemeriksaan kadar neutrofil darah. Hasilnya menunjukkan kadar neutrofil dalam rentang normal pada seluruh responden. Namun ada perbedaan signifikan antara kelompok responden yang bugar dan kelompok yang tidak bugar (Huldani dkk, 2020).

Studi oleh Julia Kasab menjelaskan bahwa terjadi peningkatan jumlah limfosit 30 menit setelah latihan fisik intensitas sedang dari kelompok sampel terlatih dan tidak terlatih dibandingkan sebelum latihan fisik. Tetapi perbedaan antara kedua kelompok tidak berarti secara uji statistik. Hal ini dapat dipengaruhi oleh jenis kelamin, penyakit bawaan, dan kebugaran individu. Penelitian Rooney dkk mendukung bahwa limfositotis terjadi pada 30-60 menit setelah latihan akut. Limfosit dan monosit akan keluar dengan cepat dan

dipengaruhi lagi oleh waktu pengambilan darah kateter intravena. Kadar limfosit tergantung pada faktor hemodinamik setelah penghentian latihan fisik, kemungkinan besar hal ini juga dipengaruhi oleh tingkat kebugaran individu (Rooney dkk, 2018).

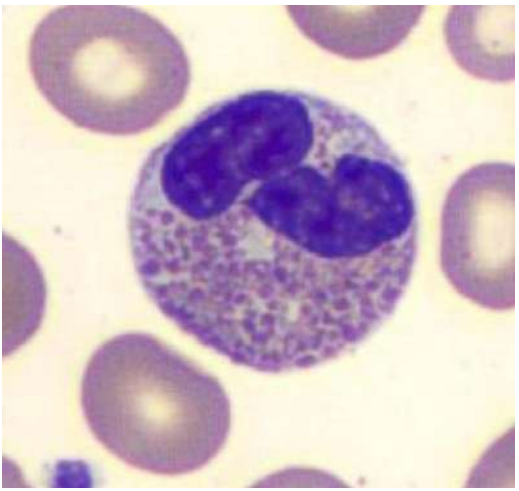
Harun menyebutkan dalam penelitiannya ada perbedaan kadar IL-6 dan limfosit setelah senam aerobik ringan dan sedang pada remaja. Dalam penelitian ini memiliki hasil yang berbeda, mungkin karena perbedaan pembagian kelompok subjek penelitian dan bentuk latihan yang diberikan. Pada penelitian Harun, subjek penelitian dibagi menjadi 3 kelompok (ditambah variabel kontrol) dan latihan yang dilakukan termasuk kronis karena dilakukan selama 12 minggu (Harun dkk, 2018).

Kadar limfosit hanya meningkat saat melakukan latihan, dan perlahan kembali menurun setelah selesai latihan (Prayuda dkk, 2017). Penelitian giacco dll menjelaskan bahwa tidak ada perubahan limfosit yang signifikan pada atlet sepak bola profesional setelah latihan. Hasil ini mungkin dipengaruhi oleh jenis kelamin khusus laki-laki, rentang usia yang sempit, dan populasi yang tidak terkontrol. Salah satu hal yang menarik adalah ternyata latihan fisik aerobik menurunkan produksi IL-4. Latihan fisik aerobik 12 menit dapat bermanfaat dalam memperbaiki gejala alergi dan penderita asma jika sering

melakukan latihan fisik secara teratur. Jadi latihan fisik aerobik secara teratur dianggap sebagai terapi bagi penderita asma (Del Giacco dkk, 2014).

c. Eosinofil

Sebanyak 6% komponen sel nukleasi sumsum tulang yang tersisa dan secara rutin diukur sebagai bagian dari jumlah sel darah lengkap adalah dibentuk oleh eosinofil. Sel imun ini berperan dalam perlawanan parasite (Wibowo dkk, 2019). Normalnya eosinofil dalam darah tepi hanya dalam kadar yang rendah, berkisar antara <450-500 sel/mL (Flores-Torres dkk, 2019).



Gambar 8. Eosinofil Pewarnaan Giemsa
Sumber: https://imagebank.hematology.org/atlas/60934

Penelitian oleh penulis dkk terhadap pemain basket menunjukkan tidak ada perbedaan signifikan kadar eosinofil pada kelompok pemain basket dan kelompok bukan pemain

basket. Kemungkinan hal tersebut terjadi karena latihan yang diberikan peneliti tidak menyebabkan cedera otot rangka pada pemain bola basket dan bukan pemain bola basket menurut penelitian Setyohadi. Hasil tersebut tidak bermakna secara statistik dan perbedaan jumlah eosinofil setelah dilakukan perlakuan pada ketiga kelompok yaitu kelompok senam aerobik ringan, kelompok senam aerobik sedang dan kelompok kontrol (Setyohadi, 2016). Penelitian lain juga mendukung hasil tersebut, ditemukan perbedaan yang signifikan antara latihan renang sekeras mungkin pada mencit, karena sesuai dengan latihan yang mampu memberikan lesi otot (Harahap, 2008).

Pada penelitian Sodique dkk diperoleh hasil yang signifikan dengan melakukan latihan fisik yang berat pada subjek dengan usia rata-rata 22 tahun dan eosipenia terjadi akibat aktivitas fisik yang berlebihan (Sodique dkk, 2000). Penelitian Yuliarto H menemukan hasil yang tidak signifikan pada latihan aerobik intensitas sedang (Yuliarto, 2001).

Selain itu, penyebab hasil hitung eosinofil yang tidak bermakna kemungkinan berasal dari latihan fisik yang dilakukan oleh pemain bola basket dan non pemain bola basket yang mengalami peningkatan kortisol yang menekan proses inflamasi sehingga menghambat jumlah eosinofil. Oleh karena itu, pada penelitian ini terdapat efek anti inflamasi yang

dihasilkan dari kortisol yang menyebabkan penekanan jumlah eosinofil, sehingga tidak terdapat perbedaan yang signifikan antara pemain bola basket dan non pemain bola basket.

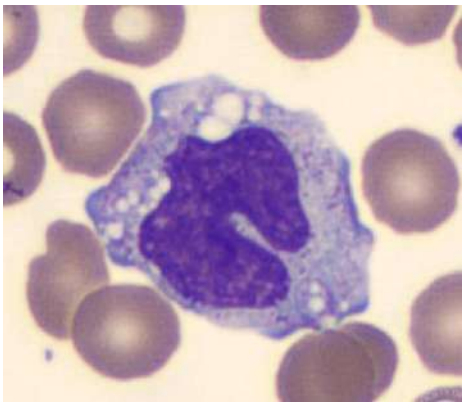
d. Monosit

Monosit adalah sel darah putih, dengan ukuran maksimum sekitar 18 m, inti padat, dan bengkok seperti ginjal atau biji kacang. Sitoplasma tidak mengandung granula dan memiliki umur sirkulasi 20-40 jam. Nukleus biasanya eksentrik dan memiliki lengkungan berbentuk tapal kuda yang dalam. Lisosom primernya yaitu butiran azurofil berjumlah lebih banyak tetapi lebih kecil. Jumlah monosit adalah sekitar 3-8% dari jumlah total sel darah putih. Monosit memiliki dua fungsi. yakni memfagosit mikroorganisme (terutama jamur dan bakteri) dan terlibat dalam respon imun (Kiswari, 2014).

Sel ini memiliki sedikit retikulum endoplasma, beberapa preribosom, dan banyak mitokondria. Aparatus Golgi berkembang dengan baik dan mikrofilamen dan mikrotubulus dapat dilihat di area lekukan nukleus. Monosit ditemukan dalam darah, jaringan ikat, dan rongga tubuh. Monosit diklasifikasikan sebagai fagosit mononuklear (sistem endotel retikuler) dan memiliki situs reseptor pada permukaan membran (Effendi, 2003).

VO2 max tidak hanya digunakan untuk menilai status kebugaran, tetapi juga merupakan parameter yang baik untuk

menilai sistem kardiopulmoner dan risiko aterosklerosis. Dalam penelitian Michishita dkk terhadap wanita obesitas, menunjukkan korelasi negatif antara VO2 max dan monosit. Semakin baik status kebugaran, semakin rendah jumlah monosit. Dari hasil tersebut diyakini bahwa status kebugaran yang baik dapat menurunkan status inflamasi seseorang, sehingga akan berimplikasi baik pada kejadian kardiovaskular (Roitt dkk, 2011; Michishita dkk, 2008; Achmad dkk, 2019).



Gambar 9. Monosit Pewarnaan Giemsa
Sumber: https://imagebank.hematology.org/atlas/60935

2. DAMP dan HMGB-1

Tubuh memiliki sinyal bahaya endogen yang disebut *damage-associated moleculer patterns* (DAMP) untuk menekan respons inflamasi sekunder terhadap pelepasan faktor inflamasi intraseluler ke ruang ekstraseluler. H*igh mobility group box 1* (HMGB1) merupakan salah satu protein

DAMP yang menjadi penanda kerusakan sel otot dan menginduksi mobilisasi sel imun ke tempat jaringan yang mengalami cedera.[4]

DAMP dapat diproduksi tidak hanya sebagai akibat dari kerusakan sel yang disebabkan oleh infeksi, tetapi juga sebagai akibat dari penyebab lain misalnya racun kimia, luka bakar, trauma, atau berkurangnya suplai darah. DAMP juga berkaitan dengan adanya kejadian apoptosis. Produksi DAMP ini dirangsang oleh sel-sel sistem kekebalan tubuh yang sehat, sel tersebut disebut alamin. Sehingga dengan rilisnya DAMP, respons imun bawaan terhadap infeksi akan meningkat (Abbas et al., 2015).

Seseorang yang berolahraga dengan intensitas yang berat memiliki kemungkinan untuk mengalami cedera atau kerusakan otot, meskipun jarang, atau kondisi yang mengancam jiwa seperti rhabdomyolisis (Goh dkk, 2018). Pada kasus cedera seperti itu, akan terjadi kondisi yang disebut respon inflamasi sekunder sebagai akibat pelepasan faktor inflamasi intraseluler ke bagian ekstraseluler. Ini kemudian akan menyebabkan sinyal bahaya endogen yang disebut pola molekul yang terkait dengan kerusakan (DAMP).

Alarmin merupakan molekul endogen yang berperan dalam fungsi fisiologis homeostasis, tetapi dapat diproduksi dengan cepat sebagai akibat dari kerusakan sel akibat stres, infeksi atau trauma. Ada beberapa jenis alarmin berdasarkan

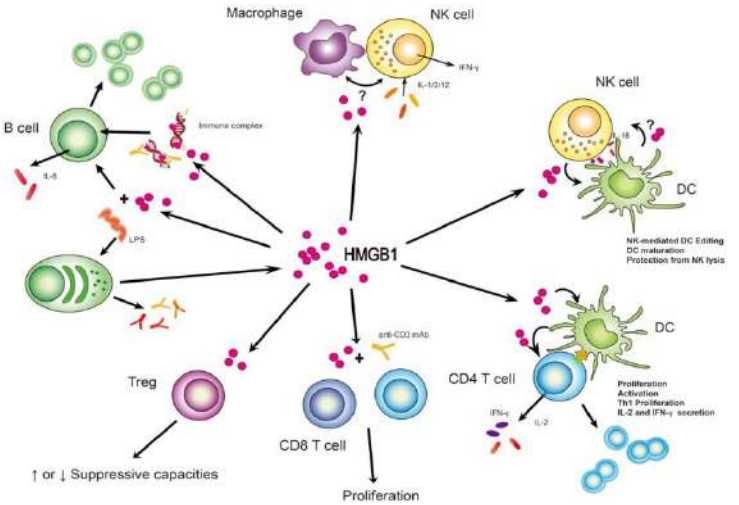
letak kompartemen seluler di mana ia berada. Berikut beberapa contoh DAMP:

a. Protein terinduksi stress
b. HSPs
c. Kristal Monosodium urat
d. Protein nuclear
e. HMGB1

Diantara contoh tersebut, *high mobility group box-1* (HMGB1) adalah jenis DAMPs yang paling terkenal. HMGB1 merupakan jenis alarmin yang ada di dalam nukleus dan berikatan dengan DNA.15 HMGB1 yang beredar dalam sirkulasi membentuk heterokompleks dengan 12 kemokin motif CXC (CXCL12) (Goh dkk, 2018). HMBG1 yang diaktifkan akan berikatan dengan PRR dalam sel imun untuk berkontribusi pada sinyal proinflamasi. menginduksi sitokin, seperti pelepasan TNF alfa, TLR-4 dan reseptor kemokin reseptor CXC 4 (CXCR4). Kemudian, CXCR4 yang menginduksi aktivasi mikroglial, fosforilasi MAPK p42/44 dan ekspresi interleukin 6 dan TNF alpha (Masson dkk, 2015).

HMGB-1 dilepaskan sebagai sinyal bahaya kerusakan sel otot sehingga mengaktifkan dan memicu mobilisasi sel imun menuju lokasi target. Level HMGB1 akan kembali ke konsentrasi semula setelah 30 menit istirahat setelah berolahraga. Tidak semua latihan dapat memicu peningkatan

HMGB1 yang berarti secara sistemik. Salah satu penelitian yang melihat kadar HMGB1 pada plasma responden yang melakukan latihan berupa balap sepeda sejauh 1200 km, didapatkan hasil yang justru berbanding terbalik dengan hasil penelitian lainnya. Meskipun ada kesalahan teknis dalam pemeriksaan plasma dan pengaruh fenomena biologis dalam penelitian ini tidak dapat dikesampingkan (Goh dkk, 2018).



Gambar 10. HMGB-1 sebagai sitokin sentral bagi seluruh sel limfoid dan HMGB1 merangsang fungsi efektor dari sel imunitas
Sumber: Li dkk, 2013

Hasil latihan akut dengan program latihan latihan dapat menyebabkan respon inflamasi yang tinggi dengan peningkatan sitokin proinflamasi dan anti inflamasi (IL6, IL8, IL10, IL1 beta, dan TNF alpha). Tingkat IL1 beta dan TNF alpha lebih tinggi pada pria daripada wanita, baik pada awal dan setelah latihan. Latihan dengan program latihan dapat

meningkatkan kadar IFN, TNF alfa, IL-6, IL-8, IL1B, VEGF dan MCP. Pada latihan aerobik tidak ada perubahan signifikan kadar TNF alfa dan IL-6 tetapi terjadi peningkatan jumlah neutrofil.

Secara keseluruhan, DAMPs memicu pelepasan sitokin masif termasuk TNF- -1, IL-6, IL-8, IL-12 dan IFN tipe I dan II. Mediator ini memperkuat aktivasi, pematangan, proliferasi, dan perekrutan sel imun di lokasi trauma, menyebabkan aktivasi tidak langsung sel imun bawaan dan adaptif seperti sel DC atau T (Jurimae dkk, 2018). Paparan HMGB1 dalam kultur monosit manusia merangsang pelepasan beberapa proinflamasi sitokin termasuk tumor necrosis factor (TNF), interleukin (IL)-1, IL-6, IL-8 dan *inflammatory protein macrophages* 1 (MIP-1). Respon kinetik terhadap pelepasan TNF yang dimediasi oleh HMGB-1 dan LPS sangat berbeda. Pelepasan TNF yang diinduksi oleh HMGB1 bersifat bifasik dengan penundaan gelombang kedua, sedangkan pelepasan TNF yang dimediasi oleh LPS hanya terjadi pada mode monofasik awal (Achmad dkk, 2019; Mickael dkk, 2018; Achmad, 2018; Huan dkk, 2015; Dashottar dkk, 2015).

Kerusakan dan cedera otot merupakan salah satu risiko yang mungkin terjadi saat berolahraga, terutama bagi para atlet. Salah satu penanda kerusakan otot adalah rilisnya kreatinin kinase sebagai respons terhadap kerusakan otot

rangka dan otot jantung pada infark miokard. Meskipun memiliki keterbatasan, kadar kreatinin kinase masih digunakan sebagai biomarker untuk kerusakan otot. Setelah biomarker dilepaskan ke dalam sirkulasi, sel imun pada tingkat jaringan atau sel imun naif akan bermigrasi ke jaringan target yang rusak dan berdiferensiasi menjadi makrofag proinflamasi matur dan berfungsi untuk fagosit, membersihkan debris dan mendegradasi jaringan yang rusak.

Makrofag yang matang juga akan melepaskan beberapa faktor pertumbuhan, sitokin, dan molekul lain sebagai sinyal untuk memulai proses inflamasi. Selama proses inflamasi ini, makrofag berubah menjadi komponen anti inflamasi dan melepaskan faktor pertumbuhan serta sitokin dengan jenis dan fungsi yang berbeda dari sebelumnya untuk mendukung proses penyembuhan.

3. Sitokin Pro-Inflamasi

Latihan dan olahraga juga memicu peningkatan stress oksidatif, peningkatan kortisol serum dan tingkat CRP plasma (Sugiharto, 2012; Nuryadi dkk, 2018). Respon proinflamasi ini diikuti oleh efek anti inflamasi jangka panjang. Latihan yang teratur akan menurunkan CRP, IL-6 dan TNF alfa serta meningkatkan substansi anti inflamasi seperti IL-4 dan IL-10. Pada orang usia muda yang sehat, program latihan aerobic dengan intensitas tinggi selama 12 minggu akan menurunkan rilisnya sitokin dan monosit. Bahkan, kegiatan fisik yang

dilakukan saat waktu luang, misalnya berjalan santai, *jogging,* atau lari, juga akan menurunkan konsentrasi CRP sensitivitas tinggi dengan kadar yang bertingkat (Nuryadi dkk, 2018).

Kontraksi otot secara langsung menginduksi pelepasan IL-6 yang merupakan bagian dari kemokin dan berperan dan mengatur pertumbuhan otot.6 IL-6 memiliki efek positif dalam penyerapan glukosa dan oksidasi lemak, selain itu, dalam perannya sebagai sitokin antiinflamasi, IL-6 melemahkan produksi TNF alfa dan IL-1 beta di mana keduanya diketahui terbentuk pada reaksi fase akut dan selama proliferasi sel (Terink dkk, 2018).

Penelitian sebelumnya telah melaporkan bahwa latihan daya tahan tunggal yang berkepanjangan dapat menyebabkan peningkatan akut pada berbagai varian sitokin inflamasi, seperti IL-2, IL-6, IL-8, IL-8, IL-10, IL-1B, TNF-alfa, gamma interferon, protein monosit-1 monosit (MCP-1) dan faktor perangsang koloni makrofag granulosit pada atlet ketahanan pria. Namun, hanya ada informasi yang sangat terbatas yang tersedia untuk wanita yang aktif secara fisik, di mana satu latihan aerobik telah dilaporkan tidak memiliki efek atau dapat menyebabkan peningkatan pasca-latihan pada beberapa sitokin inflamasi. Sitokin inflamasi yang paling banyak dipelajari adalah IL-6, TNF alfa dan IL-1 sebagai hasil dari sesi latihan tunggal yang menghasilkan respon inflamasi akut.

Namun, penyelidikan lain tidak menemukan perubahan kadar sitokin inflamasi ini setelah latihan akut

Orang yang kelebihan berat badan (obesitas) memiliki kadar IL-6 dan TNF-alfa yang lebih tinggi daripada orang dengan berat badan normal. Hal ini dikarenakan penimbunan trigliserida pada adipositas menyebabkan hipertrofi adipositas sehingga akan terjadi peningkatan sitokin pro inflamasi salah satunya neutrofil yang merupakan sel imun pertama yang merespon saat terjadi inflamasi dengan menginfiltrasi ke dalam jaringan adiposa kemudian menstimulasi jaringan adiposa. masuknya makrofag M1. Makrofag ini memicu peningkatan produksi alfa IL-6 dan TNF (Hadiono dkk, 2018).

Diketahui bahwa latihan intensitas sedang (Moderate Intensity Training atau MIT) efektif dalam mengurangi lemak tubuh. Kadar lemak yang rendah ini akan mencegah kerusakan sel lemak dan kemungkinan terjadinya hipoksia sel, sehingga akan menurunkan sitokin proinflamasi yaitu IL6 dan TNF, melalui peningkatan sekresi adiponektin dan peningkatan sitokin antiinflamasi (Hadiono dkk, 2018).

Sedangkan olahraga dengan intensitas berat (*High Intensity Interval Training* atau HIIT) diketahui efektif dalam meningkatkan profil lipid dan pelepasan sitokin anti inflamasi karena ketika seseorang melakukan HIIT terjadi kontraksi otot yang menyebabkan aktivitas mitokondria menjadi maksimal secara enzimatis. reaksi. Hal ini akan meningkatkan ambilan glukosa pada otot rangka yang pada akhirnya juga akan

menyebabkan peningkatan sekresi adiponektin (Hadiono dkk, 2018).

Gambar 11. Beberapa contoh gerakan HIIT
Sumber: https://rejuvage.com/wp-content/uploads/2019/04/feat.jpg

Suatu penelitian dilakukan pada 39 mencit obesitas untuk mengamati perbedaan kadar alfa TNF dan IL6 setelah dilakukan latihan selama 6 minggu dengan frekuensi 4 kali seminggu. minggu antara kelompok tikus dengan latihan intensitas tinggi (HIIT), kelompok tikus dengan latihan intensitas sedang (moderate intensity training atau MIT) dan kelompok kontrol yang tidak melakukan latihan. Hasil penelitian menunjukkan bahwa kelompok MIT dan HIIT memiliki kadar alfa TNF yang lebih tinggi secara signifikan dibandingkan dengan kelompok kontrol, tetapi tidak terdapat

perbedaan kadar alfa TNF yang signifikan antara kelompok MIT dan HIIT. Sedangkan kadar IL-6 pada kelompok HIIT secara signifikan lebih rendah daripada MIT dan kelompok kontrol (Hadiono dkk, 2018).

Penelitian lain yang dilakukan pada kelompok responden yang melakukan program latihan selama 4 minggu, menunjukkan bahwa kadar IFN gamma dan TNF alpha pada kelompok tersebut tidak memiliki perbedaan yang signifikan antara sebelum dan setelah 4 minggu latihan. Dalam jurnalnya, Marques dkk mengatakan bahwa hasil berbagai penelitian tentang hubungan olahraga dengan kadar sitokin tidak begitu konsisten, tidak semua penelitian menunjukkan peningkatan sitokin setelah berolahraga. Salah satunya penelitian terhadap kelompok yang melakukan pelatihan selama 32 minggu, hasilnya sebenarnya tidak menunjukkan pengaruh yang signifikan terhadap kadar sitokin pada beberapa responden yang lebih tua (Rich, 2016).

LaVoy dkk dalam jurnalnya menyatakan bahwa hasil penelitian secara konsisten menunjukkan bahwa latihan aerobik akut pada manusia tidak mengubah aktivitas sitokin sel T dan kekuatan latihan tidak mengubah kadar TNF alpha dan IFN gamma pada individu dengan tipe 2 diabetes. Namun, hasil Tierra et al. menunjukkan bahwa latihan renang selama 12 minggu menyebabkan peningkatan gamma IFN dan TNF alfa pada mencit yang menjadi subjek penelitian. Dan penelitian yang sama oleh Lamprecht dkk dengan subjek

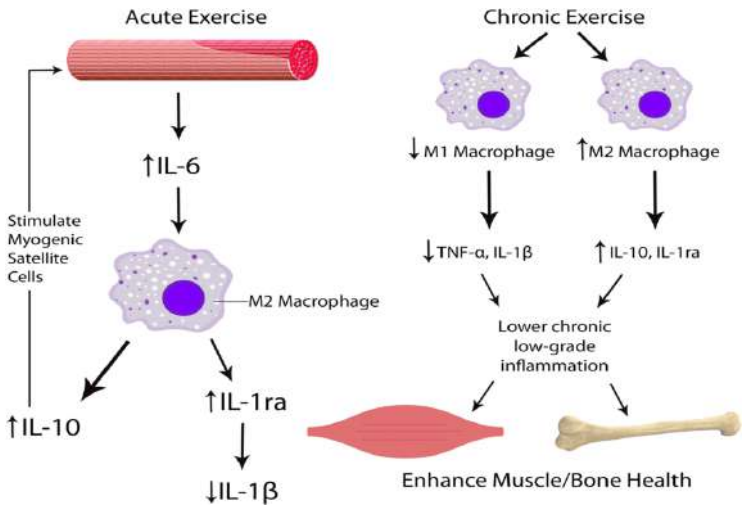
penelitian berupa kuda menunjukkan hasil peningkatan kadar gamma IFN. Semua studi ini menunjukkan hasil yang berbeda dan tidak konsisten. Hal ini bisa disebabkan karena perbedaan jenis, durasi, intensitas dan subjek penelitian (Rich, 2016).

Penelitian juga menunjukkan bahwa besarnya respon IL6 setelah latihan kekuatan tergantung pada penurunan energi seluler dan peningkatan stres panas yang kemudian terkait dengan hormon stres. Respon ini akan ditekan oleh peningkatan suplai energi dan intervensi pendinginan tubuh. Menurut Katsuhiko dalam jurnalnya, olahraga yang dilakukan pada malam hari akan memicu pelepasan IL6 lebih banyak daripada olahraga pagi (Suzuki, 2018).

Penelitian oleh Richard dkk terhadap dewasa muda sehat yang menjalani latihan aerobik acak (bersepeda, berenang, dll) selama 12 minggu. Hasil penelitian menunjukkan peningkatan VO2 max sebesar 15% dan peningkatan massa lemak bebas pada kelompok yang melakukan program latihan dan hal ini tidak terjadi pada kelompok kontrol yang tidak melakukan latihan. Hipotesis dalam penelitian ini adalah olahraga akan menurunkan induksi pelepasan TNF alfa, IL6 dan TLR4. Namun ternyata hasil hipotesis tersebut salah. Namun, analisis post hoc menunjukkan bahwa olahraga memicu respons alfa IL6 dan TNF terhadap stimulasi lipopolisakarida, hal ini

konsisten dengan kemungkinan efek positif olahraga aerobik terhadap kesehatan (Sloan dkk, 2018).

Penelitian oleh Dimitrov dkk menunjukkan adanya regulasi penurunan produksi TNF monositik selama latihan akut yang dimediasi oleh tingginya kadar epinefrin. Kontraksi otot secara langsung menginduksi pelepasan IL-6 yang merupakan sitokin anti inflamasi, bekerja untuk melemahkan produksi TNF alfa dan IL1 beta dimana keduanya telah diketahui akan terbentuk pada reaksi fase akut dan selama proliferasi sel.



Gambar 12. Efek latihan fisik akut dan kronik terhadap sel imunitas
Sumber: Cornish dkk, 2020

Latihan dengan intensitas sedang (*Moderate Intensity Training* atau MIT) efektif menurunkan lemak tubuh, kondisi ini mencegah kerusakan sel lemak serta mencegah hipoksia sel, sehingga sitokin proinflamasi, yakni IL6 dan TNF,

menjadi berkurang melalui peningkatan sekresi adiponektin dan peningkatan sitokin anti inflamasi. Latihan dengan intensitas berat (*High Intensity Interval Training* atau HIIT) diketahui efektif dalam meningkatkan profil lipid dan rilisnya sitkoin anti inflamasi karena saat seseorang melakukan HIIT maka terjadi kontraksi otot yang menyebabkan aktifitas mitokondria menjadi maksimal dalam reaksi enzimatik. Hal ini akan meningkatkan ambilan glukosa di otot rangka yang akhirnya juga akan menyebabkan peningkatan sekresi adiponektin (Huldani, Pattelongi, dkk 2020; Huldani, Asnawati, dkk, 2019).

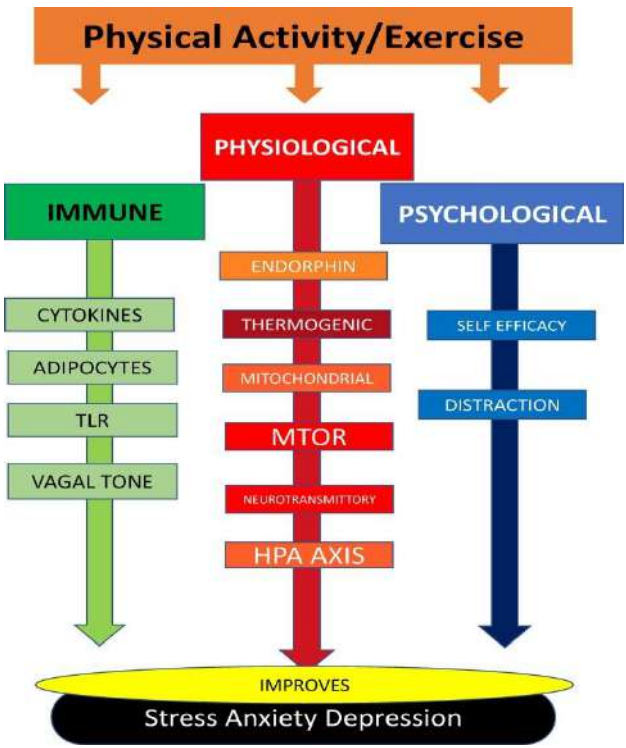
BAB IV
PENGARUH OLAHRAGA TERHADAP METABOLISME HORMONAL

Bagian terpenting dari sistem pengaturan tubuh terhadap stress adalah *corticotropin-releasing hormone* (CRH) dan sistem lokus *ceruleus* norepinefrin beserta efektor perifernya, aksis hipotalamus-pituitari-adrenal (HPA) dan sistem otonom (Chrousos, 2000). Latihan sebagai salah satu pemicu stres, karena menimbulkan peningkatan kebutuhan energi dan menyebabkan ketidakseimbangan homeostasis (Corozza dkk, 2014).

Latihan merupakan stimulus yang kuat terhadap aksis HPA. Latihan daya tahan tidak berpengaruh secara tetap terhadap hiperkortikolisme karena penanda biologis pada aksis HPA latihan sama dengan yang tidak latihan di saat istirahat pada pria sehat. Selama latihan, aksis HPA berespon terhadap banyak rangsangan yang mencerminkan regulasi dan fungsi integrasi dari aksis HPA, yakni sinyal homeostasis neural (stimulasi kemoreseptor, baroreseptor, osmoreseptor), sinyal sirkulasi homeostasis (glukosa, leptin, grelin dan peptida natreutik atrial) serta sinyal inflamasi (IL-1, IL-6 dan TNF alfa) (Duclos dkk, 2016; Huldani, Asnawati, dkk, 2019)

Intensitas dan lama latihan yang dilakukan adalah dua faktor utama yang merangsang respon aksis HPA (Duclos dkk, 2016). Jenis latihan yang berbeda dapat menimbulkan efek

yang berbeda juga pada sistem hormonal, dimana respon hormon yang lebih besar ditunjukkan pada latihan kekuatan. Kadar kortisol akan meningkat sesuai dengan tingkat rangsangan yang diberikan melalui latihan. Latihan intensitas tinggi akan menimbulkan peningkatan aktivitas hormon stress seperti kortisol, ACTH, dan katekolamin, yang menyebabkan penghambatan sintesis protein dan memicu degradasi protein yang menyebabkan pecahnya protein otot rangka (Corozza dkk, 2014).



Gambar 13. Dampak olahraga pada sistem imunitas dan fungsi fisiologis tubuh termasuk sistem hormonal
Sumber: Mikkelsen dkk, 2017

Glukokortikoid endogen yang utama dalam tubuh adalah kortisol yang merupakan hormon steroid yang di produksi dan disekresi oleh zona fasikulasi di korteks adrenal (Corozza dkk, 2014). Konsentrasi kortisol normal memiliki rentang yang luas, yakni 601-689 nmol/L di vena adrenalis kanan dan 331-335 nmol/L di vena adrenalis kiri. Kadar kortisol dalam sirkulasi diatur oleh aksis hipotalamus-pituitari-adrenal (HPA) yang dapat terjadi setelah melakukan aktivitas aerobik akut, serta akibat respon neuroendokrin yang bisa diaktivasi dengan stimulus fisiologis, seperti stres, penyakit misalnya depresi dan cushing sindrom, serta dengan latihan (Corozza dkk, 2014, Bryant, 2017).

Stres dapat terjadi secara fisik dan psikilogis, keduanya sama-sama memicu pelepasan hormon stress, misalnya kortisol. Aktivitas fisik yang berat (tidak pada aktivitas sedang) dan stress psikis sama-sama meningkatkan konsentrasi kortisol dalam saliva. Bahkan tidak ditemukan adanya perbedaan signifikan antara tingginya konsentrasi saliva pada orang yang mengalami stress fisik dengan stres psikis (Ponce dkk, 2019). Bahkan, pada neonatus konsentrasi kortisol saliva lebih tinggi pada bayi dengan *rooming-in care* parsial dibandingkan pada bayi dengan *rooming-in care* penuh. Hal ini karena melalui *rooming-in care*, ibu dapat memberikan ASI dan terjadi kontak ibu-anak sehingga menurunkan reaksi stress pada neonatus tersebut (De Bernardo dkk, 2018).

Berdasarkan jenis kelamin, hasil penelitian oleh Lovallo dkk menunjukkan respon kortisol terhadap stress psikis lebih kecil pada wanita dibandingkan pada pria (De Bernardo dkk, 2018). Hasil penelitian terhadap 46 orang remaja laki-laki dan perempuan berusia 10-12 tahun menunjukkan adanya korelasi positif antara tinggi kadar kortisol dalam rambut dengan tanda-tanda stress pada remaja laki-laki. Sebaliknya pada remaja perempuan justru konsenstrasi kortisol yang lebih rendah dalam rambut dan saliva. Hal tersebut terjadi karena tanda stress yang dialami remaja laki-laki berkaitan dengan konsentrasi kortisol jangka panjang dalam rambut, sedangkan tanda kecemasan pada remaja perempuan berhubungan dengan hipoaktivitas dari aksis HPA (Lu dkk, 2018).

Kadar kortisol paling sering diukur dari spesimen saliva, tujuannya untuk mengetahui tingkat stres seseorang. Pemeriksaan dengan sampel ini lebih mudah, non invasif sehingga tidak sakit, akurat, hasilnya diketahui lebih cepat dibanding dengan menggunakan sampel urin yang merupakan cara tersering kedua digunakan. Dalam pemeriksaan kadar kortisol pada atlet, metode yang paling disarankan adalah dengan specimen darah. Hal ini karena melalui darah dapat diketahui adanya perbedaan kadar kortisol pada fase yang berbeda dalam latihan (Vale dkk, 2012).

Konsentrasi kortisol akan terus menjadi lebih tinggi seiring dengan peningkatan intensitas dan durasi latihan

(Duclos dll, 2016). Intensitas latihan sering dinyatakan dalam persentase dari nilai kapasitas aerobic maksimal atau kapasitas oksigen maksimal (VO2 max) (Huldani, Asnawati, dkk, 2019). VO2 max menggambarkan jumlah maksimal oksigen yang dapat diedarkan dari paru-paru menuju otot dalam satuan millimeter, atau dalam menit perkilogram berat badan (Huldani, Achmad, dkk, 2020). Persentase dari VO2 max minimal yang dapat menyebabkan respon aksis HPA untuk memproduksi kortisol secara signifikan adalah minimal 60% dari VO2 max (Papadopoulos dkk, 2014).

Hasil penelitian Papadopoulos dkk yang menunjukkan nilai kortisol atlet renang yang menjalani minggu tenang lebih tinggi dibanding atlet renang yang sedang dalam minggu pertandingan, masing-masing 2.7 ng/mL dan 2.5 ng/mL. Hal ini karena selama minggu tenang atlet menjalani latihan dengan durasi yang lebih lama, yakni 14-19 jam perminggu, sedangkan kelompok atlet yang akan bertanding hanya berlatih 8.5-9.5 jam perminggu (Papadopoulos dkk, 2014). Begitu pula penelitian oleh Silva dkk pada atlet renang pria dan wanita dengan spesialistik yang berbeda (sprinter, jarak jauh dan jauh dekat), hasilnya menunjukkan bahwa secara statistik tidak ada perbedaan kadar kortisol yang signifikan antara sebelum dan sesudah kompetisi pada atlet renang pria maupun wanita. Namun, secara signifikan terdapat perbedaan kadar kortisol saliva antar spesialistik. Hal ini kemungkinan terjadi karena spesialistik yang berbeda membutuhkan energi dan efek stres

yang berbeda pula, tergantung durasi dan intensitas dari masing-masing spesialistik.

Penelitian serupa oleh Hill dkk, menunjukkan bahwa olahraga dengan intensitas 60% dan 80% VO2max menyebabkan peningkatan kadar kortisol yang secara signifikan lebih besar dibanding sesi dengan intensitas latihan 40%. Artinya, latihan dengan intensitas sedang dan tinggi menyebabkan peningkatan kadar kortisol dalam plasma. Sebaliknya, latihan dengan intensitas ringan tidak menunjukkan peningkatan kadar kortisol secara signifikan, namun justru menyebabkan pengurangan dari kadar kortisol dalam sirkulasi (Hill dkk, 2008).

Dalam beberapa literatur, kortisol disebut sebagai hormone stress karena hormone ini mempengaruhi metabolism seluler dan memobilisasi sumber energy untuk digunakan dalam keadaan stress dengan cara menstimulasi proteolitik, glikogenolisis, gluconeogenesis dan lipolysis (Corazza dk, 2014). Selain itu, kortisol juga bekerja sebagai anti inflamasi dan menekan respon imun yang dapat menjadi jalan masuk bagi infeksi, hal ini berhubungan dengan meningkatnya risiko infeksi saluran pernapasan atas. Selama latihan, kortisol memicu sintesis katekolamin (Taha dkk, 2019). Katekolamin dalam sirkulasi yang diinduksi oleh stress dihipotesiskan mampu mengaktifkan reseptor adrenergic secara selektif pada sel imunokompeten yang memodulasi respon inflamasi

terhadap trauma atau toksin dari lingkungan (Grisanti dkk, 2010).

Katekolamin dianggap memicu mulainya peningkatan jumlah limfosit, sehingga akan terjadi limfopenia setelah latihan (Taha dkk, 2019). Respon katekolamin telah terbukti meningkat secara signifikan setelah lari jarak pendek (sprint) Wingate, baik pada pria maupun wanita (Voutcher, 2011).

Jika seseorang berhadapan dengan sebuah stressor, maka kortisol akan dilepas untuk mempersiapkan tubuh mengatur respon sikap dan respon fisiologis. Pada atlet, adanya perbedaan respon tersebut terlihat dari kinerjanya selama bertanding. Meningkatnya aktivitas regulasi stress juga akan menyebabkan peningkatan fokus dan perhatian serta menekan respon rasa nyeri. Sistem respirasi dan kardiovaskuler menjadi lebih cepat, katabolisme meningkat dan aliran darah dialihkan sebanyak mungkin ke sistem otak, jantung dan otot untuk menghasilkan lebih banyak energi. Oleh karena itu, stress berpotensi meningkatkan performa para atlet (Tsigos dkk, 2002).

Stres adalah ketegangan psikologis/fisiologis yang disebabkan oleh rangsangan. Mekanisme terjadinya stres diawali dengan meningkatnya *Corticotropine Releasing Hormone* (CRH). CRH yang berperan sebagai pengatur kortisol dalam darah akan disekresikan ke dalam portal hipofisis. Kemudian *Corticotropine Releasing Hormones* akan mensekresikan *Adenocortical Stimulating Hormone* (ACTH)

(Huldani, Kaidah, dkk, 2020). ACTH memicu korteks adrenal untuk mensekresikan hormon kortisol. Kadar kortisol yang tinggi dapat menekan sel-sel inflamasi. Limfosit dan makrofag merupakan sel penting dalam imunitas dan proses inflamasi. Karena limfosit berperan dalam sistem imun adaptif sedangkan makrofag berperan dalam sistem imun bawaan (Kantasa dkk, 2016).

Latihan jangka pendek dan latihan jangka panjang terbukti menjadi pemicu perubahan status redoks atlet untuk respons akut dan kronis dalam homeostasis. Biomarker dalam latihan akut memiliki efek lebih pada homeostasis redoks daripada latihan jangka panjang. Mediator inflamasi seperti IL-6 dan IL-1ra merupakan penanda sitokin yang paling sensitif dalam latihan fisik bagi atlet remaja (Varamenti dkk, 2020). Hal ini dapat berpengaruh pada akhirnya dengan hasil penelitian sehingga diperoleh tidak bermakna.

Kortisol mempengaruhi peningkatan neutrofil (VanBruggen dkk, 2011). Dan efek anti-inflamasi akibat penekanan ekspresi sitokin proinflamasi oleh peningkatan kadar kortisol akan menahan peningkatan jumlah leukosit (Coutinho dkk, 2011; Ince dkk, 2019). Pendapat ini didukung oleh hasil penelitian yang menunjukkan bahwa pemberian dosis glukokortikoid yang menyerupai kadar kortisol di bawah stres mampu menekan IL-6 dan efek ini lebih signifikan daripada pemberian dosis glukokortikoid berlebihan atau

menekan glukokortikoid (Yeager dkk, 2011). Hal ini menunjukkan bahwa peningkatan kortisol sebagai respons terhadap stres (latihan fisik) dapat mempengaruhi sistem imun.

Latihan yang terlalu berat dan berlebihan akan menyebabkan efek pada sistem endokrin dan organ tubuh, misalnya menyebabkan kondisi amenorrhea dan rendahnya densitas tulang pada wanita. Ackerman dkk melakukan penelitian terhadap wanita *eumenorrhoeic* dan *amenorrhoeic* berusia dewasa muda yang rutin melakukan latihan angkat beban. Hasilnya menunjukkan konsentrasi kortisol pada kelompok *amenorrhoeic* lebih tinggi dibanding dengan kelompok *eumenorrhoeic* dan kelompok kontrol, hal ini memiliki korelasi dengan lebih rendahnya sekresi hormon LH yang berguna untuk merangsang terjadinya ovulasi (Tsigos dkk, 2002).

Penelitian membuktikan adanya perubahan kadar kortisol secara signifikan antara sebelum latihan atau pertandingan dengan sesudahnya. Uji kadar kortisol sebelum mengikuti pertandingan dapat menjadi indikator tingkat stress dari seorang atlet yang dapat mempengaruhi respon sikap dan fisiologis tubuh, hal ini kemudian akan mendatangkan efek menguntungkan maupun merugikan dari segi performa selama pertandingan (Lu dkk, 2018).

Lautenbach dkk melakukan penelitian untuk mengetahui hubungan kortisol dengan hasil dan performa dalam 2 ronde pertandingan taekwondo pada 20 orang peserta lomba

taekwondo internasional, pria dan wanita usia 13-17 tahun. Hasilnya, kadar kortisol sebelum pertandingan dan 30 menit setelah pertandingan keduanya secara signifikan memiliki korelasi negatif dengan jumlah perolehan poin peserta selama pertandingan ronde pertama, kedua dan total poin keseluruhan. Artinya, semakin tinggi kadar kortisol maka semakin rendah perolehan poin yang dicapai dalam pertandingan. Namun, kadar kortisol saat pertandingan berlangsung tidak memiliki korelasi yang signifikan dengan perolehan total poin (Lautenbach dkk, 2018).

Secara konsisten, berbagai penelitian menunjukkan latihan dengan intensitas lebih dari 60% VO2 max akan menginduksi pelepasan kortisol dengan kadar yang lebih tinggi pada orang dewasa. Studi menunjukkan bahwa setiap remaja memiliki respon tubuh yang sama terhadap peningkatan reaksi aksis hipotalamus-pituitari-adrenal dan peningkatan respon kortisol setelah menjalani latihan. Misalnya, pada remaja usia 15 hingga 16 tahun yang melakukan latihan selama 12 menit dengan intensitas 70-85% dari denyut nadi maksimal akan didapatkan peningkatan kadar kortisol yang terlihat jelas dibanding dengan kelompok yang hanya melakukan latihan intensitas sedang (50-65% denyut nadi maksimal) (Budde dkk, 2015).

Duclos dkk meneliti perbedaan kadar kortisol plasma dan kortisol saliva antara sesi post istirahat dan sesi post

latihan dengan subjek 8 orang pelari laki-laki. Hasilnya menunjukkan nilai kortisol saliva pada sesi post latihan, baik dari plasma maupun saliva, mengalami peningkatan yang signifikan dibandingkan dengan nilai kortisol pada post istirahat. Sebaliknya, konsentrasi kortisol plasma secara statistik tidak berbeda antara post latihan dan post istirahat. Nilai *baseline* rasio kortisol lebih kecil pada sesi post istirahat dibandingkan pada sesi post latihan (Duclos dkk, 1998).

Sebagaimana penelitian Bolados dkk mengenai perbandingan kadar kortisol pada latihan *continuous aerobic exercise* (AEE) dan latihan interval intensitas tinggi (HIIT). Hasilnya menunjukkan bahwa konsentrasi kortisol 12 jam setelah intervensi secara signifikan mengalami peningkatan, baik pada responden yang melakukan AEE maupun HIIT, dibandingkan dengan kadar sebelum intervensi. Peningkatan ini kemungkinan berhubungan dengan variasi sirkadian dari hormon kortisol tersebut (Cofre-Bolados dkk, 2019).

Penelitian yang dilakukan oleh Benjamin Siart dkk terhadap kelompok atlet menunjukkan adanya peningkatan konsentrasi kortisol dalam spesimen saliva secara signifikan segera setelah bertanding dibandingkan saat 24 jam sebelum bertanding (Siart dkk, 2017). Penelitian terhadap 62 orang partisipan dengan kondisi tubuh yang sehat, dimana 31 orang diantaranya melakukan latihan intens selama 10 menit dan 31 orang sisanya melakukan jalan santai. Kemudian dilakukan pemeriksaan kadar kortisol dalam saliva, hasilnya didapatkan

peningkatan yang signifikan setelah melakukan latihan intens dibanding sebelum latihan (Zhang dkk, 2019).

Penelitian telah dilakukan dengan tujuan yang sama terhadap 71 orang atlet junior (45 orang laki-laki dan 26 orang perempuan) yang mengikuti simulasi kompetisi angkat besi, dengan menggunakan sampel darah dan saliva. Hasilnya menunjukkan bahwa setelah kompetisi olahraga intensitas tinggi terjadi peningkatan konsentrasi kortisol total dalam darah secara signifikan, baik pada atlet laki-laki maupun perempuan (Crewther dkk, 2018). Akan tetapi, tidak ditemukan perubahan signifikan kadar kortisol dalam saliva antara sebelum dan sesudah intervensi (Sanavi dkk, 2013).

Penelitian oleh Sanavi dkk. dilakukan terhadap 17 pria sehat berusia muda (rerata usia 23.33 tahun) yang terlatih (rutin menjalani latihan minimal 3 hari perminggu selama 2 tahun terakhir), mereka diminta menjalani 3 sesi latihan aerobik berupa berlari 30 menit di atas *treadmill* dengan 3 intensitas berbeda, yakni 70%, 80% dan 90% denyut nadi maksimal (DNM). Hasilnya menunjukkan peningkatan kadar kortisol serum secara signifikan pada 0 jam setelah latihan dibanding sebelum latihan. Kemudian, 1 jam setelah latihan kadarnya akan turun, baik 70%, 80% maupun 90% DNM.[29] Penelitian yang serupa oleh Mazdarani dkk terhadap subjek atlet basket yang berusia lebih muda (rata-rata usia 10.58 tahun) juga menunjukkan hasil yang sama. Pada 12 orang

remaja perempuan pemain bola basket yang menjadi subjek, didapatkan rata-rata kadar kortisol saliva sesudah mengikuti kompetisi basket naik secara signifikan dibanding sebelum kompetisi (Sanavi dkk, 2013).

Sebaliknya, penelitian terhadap responden usia tua (60-70 tahun) sebanyak 60 orang pasien, pria dan wanita, yang dibagi 3 kelompok dan diminta melakukan latihan dengan intensitas berbeda, yakni ringan (grup A), sedang (grup B) dan tinggi (grup C), justru didapatkan penurunan secara signifikan nilai median kortisol serum yang diukur dari spesimen darah setelah latihan dibandingkan sebelum latihan pada grup A dan B. Sedangkan pada grup C tidak didapatkan perbedaan signifikan nilai median kortisol serum sebelum dan sesudah latihan (Taha dkk, 2019).

Hasil yang serupa didapatkan dalam penelitian Rosa dkk terhadap sampel darah dari 10 orang pria. Setelah mengikuti 2 program latihan bersama, terjadi penurunan secara signifikan kadar kortisol serum setelah program latihan pertama dan kedua (Rosa dkk, 2016). Penelitian lain dilakukan oleh Alfredo dkk terhadap kelompok pemain bola basket selama 4 musim (Oktober, Desember, Maret dan April), hasilnya kadar kortisol basal mengalami perubahan yang signifikan selama musim pertandingan dimana kadar lebih tinggi ditemukan pada bulan Oktober dan Maret (Seco dkk, 2010).

Latihan dan olahraga dengan intensitas berat dan bersifat kompetitif memang menjadi salah satu penyebab stres

(stresor). Akan tetapi, latihan dan olahraga yang dilakukan secara berkelanjutan dengan dosis yang tepat akan menurunkan sekresi HPA Axis, hiperkortisol yang rendah, mengaktivasi sitokin proinflamasi IL-6, merangsang sekresi hormon pertumbuhan, prolaktin dan meningkatkan kekebalan tubuh dengan dirangsangnya Th2 Sehingga latihan dan olahraga yang rutin dan berkesinambungan akan mendatangkan efek positif untuk tubuh, salah satunya menambah kebugaran (Sugiharto, 2012).

Kebugaran jasmani memberikan perubahan signifikan pada sistem endokrin, yang kemudian mempengaruhi metabolisme, termasuk metabolisme protein. Kelenjar endokrin mensekresikan hormon ke dalam sirkulasi, berikatan dengan reseptor spesifik di sel target, dan berefek terhadap ekspresi gen yang spesifik. Pada sel otot, kortisol merupakan satu-satunya hormon yang merangsang degradasi protein. Pelepasan hormon kortisol akibat stres dapat mengaktivasi sistem saraf simpatis yang salah satunya ditandai dengan peningkatan frekuensi nadi. Kadar hormon kortisol dalam darah yang tinggi juga dapat mengurangi kemampuan berpikir dan bereaksi seseorang. Hormon kortisol juga berperan dalam terjadinya penurunan mood dan kelelahan otot (Nuryadi dkk, 2018).

Akan tetapi, hasil penelitian oleh Nuryadi dkk. menunjukkan bahwa terdapat korelasi fungsional yang negatif

yang sangat bermakna antara kebugaran jasmani dengan respon kortisol yakni -0,203 hal ini berarti semakin tinggi kebugaran jasmani maka semakin rendah respon kortisol dengan nilai kontribusi sebesar 4,12%. Peneliti menduga bahwa daerah tempat tinggal akan memengaruhi terhadap kebugaran jasmani, kemampuan konsentrasi dan respon kortisol, dimana ditemukan perbedaan persentase kontribusi kebugaran jasmani terhadap respon kortisol antara responden di dataran tinggi dan dataran rendah, yakni berturut-turut 4.12% dan 8.47% (Nuryadi dkk, 2018).

Terkait pengaruh waktu melakukan latihan terhadap kadar kortisol, penelitian oleh Haslinda pada 10 orang subjek yang diberi intervensi berupa latihan futsal pada malam hari dan 8 orang subjek control, menunjukkan bahwa tidak ada efek signifikan terhadap kadar kortisol. Haslinda menyimpulkan bahwa kegiatan futsal tetap dapat dilakukan dimalam hari dengan intensitas ringan hingga sedang dalam waktu yang tidak begitu lama karena tidak mempengaruhi konsentrasi kortisol dalam plasma (Haslinda, 2018).

Haslinda juga melakukan penelitian yang sama pada subjek yang melakukan kegiatan futsal di pagi hari. Hasilnya menunjukkan adanya peningkatan kadar kortisol setelah futsal dibanding sebelumnya, namun secara statistik nilai tersebut tidak bermakna signifikan. Justru kelompok kontrol yang tidak melakukan kegiatan futsal mengalami peningkatan kadar kortisol serum yang bermakna. Hal ini dapat disebabkan oleh

adanya siklus sirkadian dimana kadar sekresi kortisol berada pada level tertinggi. Sekresi kortisol serum mulai meningkat pada pertengahan malam hari, mencapai puncaknya pada pagi hari. Selain dari itu, kemungkinan peningkatan ini disebabkan adanya faktor lain yang dapat meningkatkan sekresi kortisol, yaitu stres psikologis yang juga memicu rilisnya kortisol, sebagaimana yang telah dibahas sebelumnya (Haslinda dkk, 2017).

Latihan dapat dianggap sebagai pemicu cedera otot yang mengaktifkan sumbu hipotalamus-hipofisis-adrenal. Akan ada peningkatan jumlah kortisol saat pemain bola basket muda dan pemain non-basket diberikan pelatihan. Peningkatan kortisol adalah respons umum terhadap cedera otot. Oleh karena itu, latihan intensitas ringan tidak akan menyebabkan cedera otot yang mengakibatkan tidak ada perubahan kortisol. Latihan yang dapat menyebabkan cedera otot meningkatkan peningkatan kortisol. Kortisol beredar dalam plasma. Ini memobilisasi zat yang dibutuhkan untuk metabolisme sel.

Kortisol juga mempengaruhi metabolisme protein. Kortisol memiliki efek metabolik yang meningkatkan laju sintesis protein RNA di beberapa bagian tubuh dan meningkatkan laju lipogenesis di bagian lain seperti wajah dan tubuh. Pengaruh lipid pada jaringan cukup spesifik karena tidak semua bagian menunjukkan peningkatan deposisi lipid atau lipolisis. Kortisol bekerja sebagai imunosupresan dengan

menekan sintesis protein termasuk sintesis imunoglobulin. Kortisol juga mengurangi populasi eosinofil, limfosit, dan makrofag dalam darah tepi.

Glukokortikoid menurunkan jumlah eosinofil dalam darah dengan meningkatkan penyerapannya di limfa dan paru-paru. Efek khas dari distribusi kortisol pada sel darah putih mengurangi jumlah eosinofil dari biasanya 270 sel/aL menjadi 20 sel/aL. Oleh karena itu, terdapat peningkatan kortisol pada latihan akut pada latihan intensitas sedang yang mengakibatkan penekanan jumlah eosinofil dalam darah atau eosinopenia. Padahal terkesan kontradiktif karena pendapat lain menyatakan bahwa terjadinya eosinopenia relatif berkaitan dengan adanya tanda-tanda limfositosis atau penekanan proses inflamasi sehingga menghambat peningkatan jumlah eosinofil dalam darah (Yuliarto, 2001; Sabag dkk, 1978; Hotting dkk, 2016).

Penelitian lain yang dilakukan penulis dkk adalah terhadap 15 siswa SMAN 1 Banjarbaru yang merupakan atlet bola basket dan 15 siswa lainnya yang bukan atlet. Seluruh responden melakukan latihan multistage fitness test pada hari pertama, lalu istirahat pada hari kedua, dan pada hari ketiga dilakukan penghitungan nilai jantung maksimal dengan formula Tanaka. Responden dipasangi alat pulse oksimetri dan melakukan lari berkelompok hingga denyut nadi mencapai 70-90% sebagai latihan pemanasan. Setelah mencapai target responden tetap lanjut berlari selama 12 menit sebagai latihan

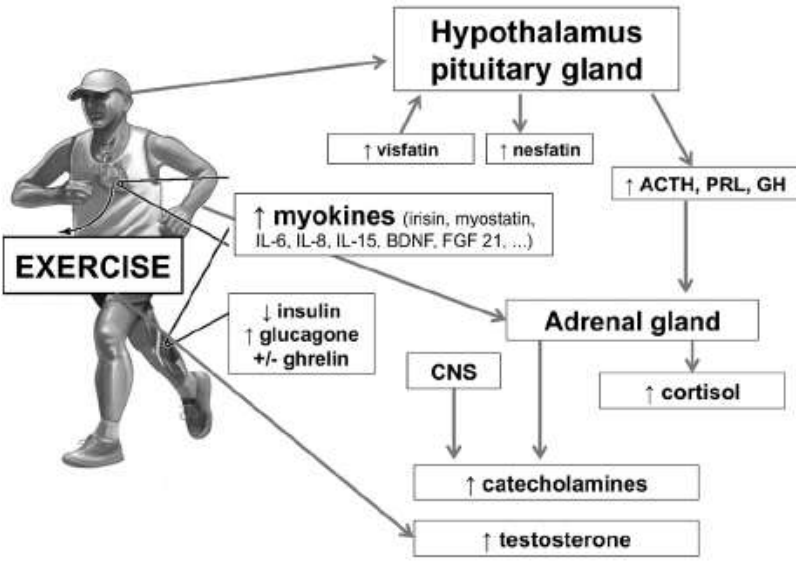
aerobic intensitas sedang. Setelah selesai lari, dilakukan pemeriksaan kadar kortisol darah. Dalam penelitian tersebut, ada perbedaan yang signifikan secara statistik kadar kortisol setelah latihan intensitas sedang antara pemain bola basket dan non-pemain bola basket (Huldani, Husairi, dkk, 2021).

Hal ini menunjukkan bahwa terdapat perbedaan yang signifikan nilai kortisol remaja latih bola basket dibandingkan dengan remaja latih bola basket setelah dilakukan intervensi lari aerobik sedang selama 12 menit. Seperti pada beberapa penelitian sebelumnya bahwa olahraga dan aktivitas fisik dapat menjadi sumber stres bagi tubuh dan berdampak pada sistem tubuh lainnya serta berpotensi mempengaruhi homeostasis (MacPherson dkk, 2011; Minetto dkk, 2007).

Olahraga mampu mempengaruhi respon aksis hipotalamus-hipofisis yang menyebabkan pelepasan hormon kortikotropin (CRH) dari hipotalamus ke sel-sel hipofisis anterior, menghasilkan pelepasan hormon adrenokortikotropik (ACTH) ke dalam aliran darah. ACTH dalam darah kemudian merangsang pelepasan glukokortikoid (kortisol) dari korteks adrenal (U.S. Department of Health and Human Services, 2013). Dalam hasil penelitian ini, kadar kortisol kelompok pemain basket lebih tinggi dibandingkan kelompok non-basket. Hasil penelitian menunjukkan kesamaan dengan penelitian oleh Minetto dkk yang mengamati kadar kortisol

saliva yang lebih tinggi pada atlet kompetitif daripada individu yang tidak aktif (Cevada dkk, 2014).

Kemungkinan alasannya adalah kelompok pemain bola basket HPA axis memiliki respons yang lebih baik terhadap stres daripada kelompok yang bukan pemain bola basket. yang penting bagi kelompok pemain bola basket dapat beradaptasi dengan situasi stres kronis seperti kompetisi dan olahraga sehari-hari (Abdossaleh dkk, 2014).



Gambar 14. Latihan fisik menyebabkan peningkatan dan penurunan kadar hormon-hormon
Sumber: Bajer dkk, 2015

DAFTAR PUSTAKA

1. Abdossaleh Z, Fatemeh A, Frozan K, Mohhammad Amin S. Leukocytes Subsets Is Differentially Affected By Exercise Intensity. Int J Sport Stud.2014; 4:246–253
2. Achmad H. Horax S, Ramadhany S, et.al. (2019). Resistivity of Ant Nest (Myrmecodia pendans) On Ethanol Fraction Burkitt's Lymphoma Cancer Cells (Invitro) Through Interleukin 8 Angiogenesis Obstacles (Il-8). Journal of International Dental and Medical Research ,.ISSN 1309-100X. Vol 12 No. (2) pp.516-523.
3. Achmad, H. (2018). Apoptosis Induction (Caspase-3, -9) and Human Tongue Squamous Cell Carcinoma VEGF Angiogenesis Inhibition using Flavonoids's Ethyl Acetate Fraction of Papua Ant Hill (Myrmecodia pendans) SP- International Dental and Medical Research. ISSN 1309-100X. (Scopus index). Volume 11 Number (1). pp. 276-284.
4. Adiputro, Julia Kasab. Differences in VO2 Max Based on Age, Gender, Hemoglobin Levels, and Leukocyte 16. Counts in Hajj Prospective Pilgrims in Hulu Sungai Tengah Regency, South Kalimantan. SRP. 2020; 11(4): 09-14. doi:10.31838/srp.2020.4.03
5. Ahmad H. Horax S, Ramadhany S, et.al. (2019). Resistivity of Ant Nest (Myrmecodia pendans) On Ethanol Fraction Burkitt's Lymphoma Cancer Cells

(Invitro) Through Interleukin 8 Angiogenesis Obstacles (Il-8). Journal of International Dental and Medical Research ,. ISSN 1309-100X. Vol 12 No. (2) pp.516-523.

6. Albayrak CD, Çiftçi S, Beylero M, et al. Association of immune parameters with stress hormone levels in elite sportsmen during the pre-competition. Int J Hum Sci. 2013;10(1):1412–20.
7. Alfian, M. (2016). Skripsi. Efektivitas peningkatan vo2max dengan metode kontinyu dan fartlek pada atlet sekolah sepakbola matra utama tahun 2016. Universitas Negeri Yogyakarta. Yogyakarta.
8. Ardhie, A. M. (2011). Radikal Bebas Dan Peran Antioksidan Dalam Mencegah Penuaan. Medicinus, 24, 4-9.
9. Arum, V.M. and Mulyati, T., 2014. Hubungan intensitas latihan, persen lemak tubuh, dan kadar hemoglobin dengan ketahanan kardiorespirasi atlet sepak bola. Journal of Nutrition College, 3(1), pp.179-183.
10. Aschendorf PF, Zinner C, Delextrat A, Engelmeyer E, Mester J. Effects of basketball-specific high-intensity interval training on aerobic performance and physical capacities in youth female basketball players. The Physician and sportsmedicine. 2019 Jan 2;47(1):65-70.

11. Astorino TA, Robergs RA, Ghiasvand F, Marks D, Burns S. Incidence of the oxygen plateau during exercise testing to volitional fatigue. J Exerc Physiol (2000); 3: 1–12.
12. Bajer B, Vlcek M, Galusova A, Imrich R, Penesova A. Exercise associated hormonal signals as powerful determinants of an effective fat mass loss. Endocrine regulations. 2015 Jul 1;49(3):151-63.
13. Boutcher, Steve. High-Intensity Intermittent Exercise and Fat Loss. Journal of obesity. 2011;2011(868305). DOI: https://doi.org/10.1155/2011/868305.
14. Bryant R. Role of BDNF val66met polymorphism in modulating exercised-induced emotional memories. Psychoneuroendocrinology.2017;77:150-7. DOI: 10.1016/j.psyneuen. versus
15. Buchan DS, Ollis S, Young JD, et al. The effects of time and intensity of exercise on novel and established markers of CVD in adolescent youth. Am J Hum Biol. 2011;23(4):517–26.
16. Budde H, Machado S, Ribeiro P and Wegner M. The cortisol response to exercise in young adults. Front. Behav. Neurosci. 2015;9(13). DOI:https://doi.org/10.3389/fnbeh.2015.00013
17. Budiarto, R.A. (2012). Hubungan Antara Indeks Massa Tubuh Dan Nilai Volume Oksigen Maksimal

(Vo2maks) Pada Mahasiswa Apikes Citra Medika Surakarta. Surakarta: UMS.

18. Cengiz A, Robert AR, Ian K. 2008. Prediction of VO2 max from an Individualized Submaximal Cycle Ergometer Protocol. JEP online 11: 3.
19. Centers for Disease Control and Prevention (CDC, 2005. Cigarette smoking among adults--United States, 2003. MMWR. Morbidity and mortality weekly report, 54(20), pp.509-513.
20. Cevada T, Vasques PE, Moraes H, et al. Salivary cortisol levels in athletes and nonathletes: A systematic review. Horm Metab Res. 2014;46(13):905–10.
21. Chevion, S, M. D., 2003, Serum antioxidant stress and cell injury after severe physicaal exercise. Proseding of The United State of America.
22. Chrousos, G. P. The role of stress and the hypothalamic pituitary adrenal axis in the pathogenesis of the metabolic syndrome: neuroendocrine and target tissue-related causes. International Journal of Obesity. 2000;24(2):S50-S55. DOI:https://doi.org/10.1038/sj.ijo.0801278
23. Clakrson, PM, T. H., 2000, Antioksidants:what role do they play in physical activity and health. j Clin Nutr.
24. Corazza DI, Sebastiao E, Pedroso RV, Andreatto CAA, Coelho FGDM, Gobbi S, et al. Influence of chronic

exercise on serum cortisol levels in older adults. European Review of Aging and Physical Activity. 2014;11:25-34. DOI: https://doi.org/10.1007/s11556-013-0126-8

25. Cornish SM, Chilibeck PD, Candow DG. Potential importance of immune system response to exercise on aging muscle and bone. Current Osteoporosis Reports. 2020 Aug;18(4):350-6.
26. Coutinho AE, Chapman KE. The anti-inflammatory and immunosuppressive effects of glucocorticoids, recent developments and mechanistic insights. Mol Cell Endocrinol [Internet]. 2011;335(1):2–13.
27. Crewther, Blair T., Zbigniew Obmiński, Joanna Orysiak, and Emad AS Al-Dujaili. "The utility of salivary testosterone and cortisol concentration measures for assessing the stress responses of junior athletes during a sporting competition." Journal of Clinical Laboratory Analysis 32, no. 1 (2018): e22197.
28. Danusantoso, Halim., (2003). Peran Radikal Bebas Terhadap Beberapa Penyakit Paru. Jurnal Kedokteran Trisakti, Januari- April 2003, Vol 22 No.1
29. Dashottar, S., Singh, A.K., Suhag, V., Sunita, Singh, R. Unusual case of congenital aneurysm of proximal pulmonary artery causing lung collapse (2015) Journal of Cardiovascular Disease Research, 6 (1), pp. 31-36. DOI: 10.5530/jcdr.2015.1.6

30. De Bernardo, Giuseppe & Riccitelli, Marina & Giordano, Maurizio & Proietti, Fabrizio & Sordino, Desiree & Longini, Mariangela & Buonocore, Giuseppe & Perrone, Serafina. (2018). Rooming-in Reduces Salivary Cortisol Level of Newborn. Mediators of Inflammation. 2018;2018:1-5. DOI: https://doi.org//10.1155/2018/2845352.
31. Del Giacco SR, Scorcu M, Argiolas F, Firinu D, Del Giacco GS. Exercise training, lymphocyte subsets and their cytokines production: experience of an Italian professional football team and their impact on allergy. BioMed research international. 2014; 2014.
32. Delany, J.P, 2013, Nutrition In The Prevention And Treatment, In B.C. In: Coulston AM, Energy Requirement Methodology, 3rd Ed. New York, Academic Press.
33. Duclos M, Corcuff JB., Arsac L, Moreau-Gaudry F, Rashedi M, Roger P, Tabarin A, and Manier G. Corticotroph axis sensitivity after exercise in endurance-trained athletes. Clinical Endocrinology. 1998;48:493-501. DOI: https://doi.org/10.1046/j.1365-2265.1998.00334.x
34. Duclos M, Tabarin A. Exercise and the Hypothalamo-Pituitary-Adrenal Axis. Front Horm Res. 2016;47:12-26. DOI: https://doi.org/10.1159/0004451

35. Ferriyanto. 2010. Volume Oksigen Maksimal Bandung: Studio Press.
36. Firman, F.B. 2016. Faktor yang berhubungan dengan kebugaran jasmani (VO2 maks) atlet sepakbola. Surabaya: Universitas Airlangga.
37. Firman, O.B., 2015. Faktor yang Berhubungan Dengan Kebugaran Jasmani (VO2 Max) Atlet Sepakbola.
38. Flores-Torres AS, Salinas-Carmona MC, Salinas E, Rosas-Taraco AG. Eosinophils and respiratory viruses. Viral immunology. 2019;32(5):198-207.
39. Ganong, William F. 2003. Fisiologi Kedokteran (20thed). Ahli Bahasa Djauhari Widjaja-kusumah, EGC. Penerbit Buku Kedokteran. Jakarta : 517-609.
40. Ganong. 2002. Buku Ajar Fisiologi Kedokteran. Jakarta: EGC.
41. Gibson, R. 2005. Principles of Nutritional Assesment. Oxford University. New York.
42. Gleeson M, Bishop N, Walsh N. Exercise immunology. Exercise Immunology. New York: Routledge; 2013. 342 p.
43. Gleeson M. Links between sedentary behavior, chronic inflammation and chronic diseases. In: Gleeson M, Bishop N, Walsh N, editors. Exercise immunology. New York; Routledeg, 2013; p. 301-8

44. Goh J, Behringer M. (2018). Exercise alarms the immune system: a HMGB1 perspective. Cytokine. 110: 222-5. https://doi.org/10.1016/j.cyto.2018.06.031.
45. Gomez-Cabrera, M.C., Domenech, E., Romagnoli, M., Arduini, A., Borras, C., Pallardo, F.V., Sastre, J. and Vina, J., 2008. Oral administration of vitamin C decreases muscle mitochondrial biogenesis and hampers training-induced adaptations in endurance performance. The American journal of clinical nutrition, 87(1), pp.142-149.
46. Grisanti LA, Evanson J, Marchus E, Jorissen H, Woster AP, DeKrey W, Sauter ER, Combs CK, Porter JE. Proinflammatory responses in human monocytes are beta1-adrenergic receptor subtype dependent. Mol. Immunol. 2010;47:1244 1254. DOI: https://doi.org/10.1016/j.molimm.2009.12.013
47. Grossmann, M. and Zajac, J.D., 2012. Hematological changes during androgen deprivation therapy. Asian journal of andrology, 14(2), p.187.
48. Guyton, A.C., dan Hall, J.E. 2008. Buku Ajar Fisiologi Kedokteran. Edisi 11. Jakarta: EGC
49. Guyton,A.C., Hall, J.E., 1997, Fisiologi Kedokteran, Jakarta, EGC
50. Hadiono, Kushartanti BMW. (2018). Effects of High Intensity Interval Training (HIIT) and Moderate

Intensity Training (MIT) on TNF- -6 in Rats. Advances in Health Sciences Research (AHSR). 7: 87- 90. http://eprints.uny.ac.id/en/eprint/60015.

51. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U, Lancet Physical Activity Series Working Group. Global physical activity levels: surveillance progress, pitfalls, and prospects. The lancet. 2012 Jul 21;380(9838):247-57.
52. Harahap NS. Pengaruh aktifitas fisik maksimal terhadap jumlah leukosit dan hitung jenis leukosit pada mencit (Mus Musculus L) jantan. USU e-Repository ©. 2008;1–24.
53. Harun L, Pascasarjana P, Muhammadiyah U, Aerobik L. Perbandingan kadar interleukin-6 dan jumlah limfosit setelah (Comparation Of The Levels Of Interleukin-6 And The Number Of Lymphocytes After Mild And Moderate Aerobic In Adolecents). 2018;1(2):64–8.
54. Hasiolan, S.R. 2017. Pengaruh jogging terhadap peningkatan VO2 max pada middle age di surakarta. [Karya Tulis Ilmiah] Surakarta: Universitas Muhammadiyah Surakarta
55. Haslinda DS, Ilhamjaya Patellongi, and Andi Wardihan Sinrang. Pengaruh Olahraga Futsal Terhadap Kadar 42. Kortisol Serum Pada Individu Dewasa Muda. In Seminar Nasional LP2M UNM. 2017;2(1)

56. Haslinda DS. The Effect of Night Futsal Sport on The Level of Cortisol Serum In Young Adults. Journal of Physics: Conferece Series. 2018;1028(1). DOI: https://doi.org/10.1088/1742-6596/1028/1/012105
57. Hatle, H., Støbakk, P.K., Mølmen, H.E., Brønstad, E., Tjønna, A.E., Steinshamn, S., Skogvoll, E., Wisløff, U., Ingul, C.B. and Rognmo, Ø., 2014. Effect of 24 sessions of high-intensity aerobic interval training carried out at either high or moderate frequency, a randomized trial. PloS one, 9(2), p.e88375.
58. Herman KM, Craig CL, Gauvin L, Katzmarzyk PT. Tracking of obesity and physical activity from childhood to adulthood: the Physical Activity Longitudinal Study. International Journal of Pediatric Obesity. 2009 Jan 1;4(4):281-8.
59. Hermawan, Soni. (2015). "Perbandingan Pengaruh Sport Massage dan Swedish Massage Terhadap Perubahan Denyut Nadi dan Frekuensi Pernapasan". UNY.
60. Hermina S, 2004. Pengaruh Latihan Aerobik dan Anaerobik terhadap Sistem Kardiovaskuler dan Kecepatan Reaksi. Artikel Kesehatan. Media Medika Indonesia 2004, 39.
61. Hill EE, Zack E, Battaglini C, Viru M, Viru A, Hackney AC. Exercise and circulating cortisol levels: the intensity

threshold effect. J Endocrinol Invest. 2008;31(7):587-91. DOI: https://doi.org/10.1007/BF03345606

62. Hodges, Larry. 2007. Tenis Meja Tingkat Pemula. Jakarta.
63. Hoeger W W K and Hoeger S A. 2010. Principles and labs for physical fitness (7th ed) (USA: Wadsworth)
64. Hötting K, Schickert N, Kaiser J, Röder B, Schmidt-Kassow M. The effects of acute physical exercise on memory, peripheral BDNF, and cortisol in young adults. Neural plasticity. 2017;2016.
65. Huan Y, Haichao W, Sangeeta SC, Ulf A. (2015). High Mobility Group Protein Box 1 (HMGB1): The Prototypical Endogenous Danger Molecule. MOL MED 21 (SUPPLEMENT 1), S6-S12.
66. Huldani, Asnawati, Auliadina D, Amilia, FR, Nuarti N, Jayanti R. Abdominal Circumference, Body Fat Percent, and VO2 Max in Pilgrims of Hulu Sungai Tengah Regency. Journal of Physics: Conference Series. 2019;1374(1). DOI: https://doi.org/10.1088/1742-6596/1374/1/012058
67. Huldani, Husairi, A., Zuhair, A., Rafagih, M., Suwanto, Z.K., Wiryawan, W. and Zaini, M., 2021. Differences Of Vo2 Max Value In Adolescents And Cortisol Levels, Count Of Leukocytes, Monocytes, And Neutrophyl After 12 Minutes Of Moderate Aerobic Exercise.

European Journal of Molecular & Clinical Medicine, 8(01), p.2021.

68. Huldani, Ilhamjaya Pattelongi, Muhammad Nasrum Massi, Irfan Idris, Agussalim Bukhari, Agung Dwi Wahyu Widodo, Harun Achmad. Research Reviews on Effects of Exercise on DAMP's, HMGB-1, Proinflammatory Cytokines and Leukocytes. SRP. 2020; 11(4): 306- 312.doi:10.31838/srp.2020.4
69. Huldani, Kaidah, S., Kasab, J. and Ridhoni, M. 2020. VO2 Max in River Beach communities in hst district by age, gender, and mobile immunity (neutrofil and limfosite). European Journal of Molecular & Clinical Medicine, 7(8), pp.1126-1132.
70. Huldani, Putra, A.P., Arsyad, A., Achmad, H., Sukmana, B.I., Adiputro, D.L. and Kasab, J., 2020. Differences in VO2 max based on age, gender, hemoglobin levels, and leukocyte counts in Hajj prospective pilgrims in Hulu Sungai Tengah Regency, South Kalimantan. Differences in VO2 Max Based on Age, Gender, Hemoglobin Levels, and Leukocyte Counts in Hajj Prospective Pilgrims in Hulu Sungai Tengah Regency, South Kalimantan, pp.09-14.
71. Huldani, Sukmana BI, Pujiningtyas A, Savitri E, Fauziah, Nihayah U. (2019). Cellular Immunity of River Water Consumption and Bandarmasih Municipal

Waterworks Consuments. Indian Journal of Public Health Research and Development. 10 (7):789-94. DOI: http://dx.doi.org/10.5958/0976-5506.2019.01674.7.

72. Huldani. 2010. Pengaruh Kadar Hemoglobin dan Jenis Kelamin Terhadap Konsumsi Oksigen Maksimum Siswa-Siswi Pesantren Darul Hijrah. 509-511.
73. Ince LM, Weber J, Scheiermann C. Control of leukocyte trafficking by stress-associated hormones. Front Immunol. 2019;10(JAN):1–9.
74. Indriyani P, Supriyanto H, Santoso A, 2007,Pengaruh Latihan Fisik Senam Aerobik Terhadap Penurunan Kadar Gula Darah pada Penderita DM Tipe 2 Di Wilayah Puskesmas Bukateja Purbalingga. Media Ners: Banyumas.
75. Ismaryati. 2009. Tes dan Pengukuran Olahraga. Semarang: Lembaga Pengembangan Pendidikan (LPP) UNS dan UPT Penerbitan dan Percetakan UNS (UNS Press).
76. Joyner, M. J. and Coyle, E. F. (2008). Endurance exercise performance : The physiology of champions Endurance exercise performance : the physiology of champions', J Physiol, 586 (Pt 1)(January 1), pp. 35–44. doi: 10.1113/jphysiol.2007.143834.
77. Jürimäe, J., Vaiksaar, S., Purge, P. (2018). Circulating Inflammatory Cytokine Responses to Endurance Exercise in Female Rowers. International Journal of

Sports Medicine..Med ISSN 0172-4622. DOI: https://doi.org / 10.1055 / a-0723-4421.

78. Kantasa VD, Kusumawardani B. The effect of electrical shock stressor on lymphocytes and macrophages in gingival tissue of sprague dawley rats. Pustaka Kesehatan. 2016; 11;4(1):48-54.
79. Katch LV, McArdle DW, Katch, IF (2011). Essential of exercise physiology, fourth edition. Lippincott Williams & wilkins, a wolter kluwer bussines, Philadelphia, PA 19103.
80. Kiswari R. (2014). Hematologi dan Transfusi. Jakarta: Erlangga.
81. Lautenbach, Franziska & Lobinger, Babett. Cortisol Predicts Performance During Competition: Preliminary Results of a Field Study with Elite Adolescent Taekwondo Athletes. Applied Psychophysiology and Biofeedback. 2018;43:1-6. DOI: https://doi.org//10.1007/s10484-018-9406-4.
82. Lee EC, Fragala MS, Kavouras SA, Queen RM, Pryor JL, & Casa DJ. (2017). Biomarkers in sports and exercise: tracking health, performance, and recovery in athletes. Journal of strength and conditioning research. 31 (10): 2920. DOI: 10.1519 / JSC.0000000000002122.

83. Li G, Liang X, Lotze MT. HMGB1: the central cytokine for all lymphoid cells. Frontiers in immunology. 2013 Mar 20;4:68.
84. Liu, A.G., Arceneaux III, K.P., Chu, J.T., Jacob Jr, G., Schreiber, A.L., Tipton, R.C., Yu, Y., Johnson, W.D., Greenway, F.L. and Primeaux, S.D., 2015. The effect of caffeine and albuterol on body composition and metabolic rate. Obesity, 23(9), pp.1830-1835.
85. Loddo, A. and Putzu, L., 2021. On the Effectiveness of Leukocytes Classification Methods in a Real Application Scenario. AI, 2(3), pp.394-412.
86. Lu Q, Pan F, Ren L, Xiao J, Tao F. Sex differences in the association between internalizing symptoms and hair cortisol level among 10-12 year-old adolescents in China. PloS one. 2018;13(3). DOI: https://doi.org/10.1371/journal.pone.0192901
87. Mackenzie, B., 2013. Sport Coach VO2 max. Tersedia di: (http://www. brianmac. co. uk/vo 2 max. htm# vo2).
88. MacPherson REK, Hazell TJ, Olver TD, et al. Run sprint interval training improves aerobic performance but not maximal cardiac output. Med Sci Sports Exerc. 2011;43(1):115–22.
89. Madina DS. (2007). Parudan's vital capacity value is related to the physical characteristics of various athletes in various sports. Bandung: Unpad.

90. Magsalmina,M. 2007. Pengaruh Latihan Aerobic terhadap Perubahan Vo2max pada Siswa Sepak Bola Tugu Muda Semarang usia 32-14 tahun. Artikel Karya Ilmiah. Semarang: Fakultas Kedokteran Undip.
91. Masson GS, Nair AR, Silva Soares PP, Michelini LC, Francis J. (2015). Aerobic training normalizes autonomic dysfunction, HMGB1 content, microglia activation and inflammation in the hypothalamic paraventricular nucleus of SHR. American Journal of Physiology-Heart and Circulatory Physiology. 309 (7). https://doi.org/10.1152/ajpheart.00349.2015.
92. McNamara RJ, McKeough ZJ, McKenzie DK, Alison JA. Water-based exercise training for chronic obstructive pulmonary disease. Cochrane database of systematic reviews. 2013(12).
93. Michishita R, Shono N, Inoue T, Tsuruta T, Node K. (2008). Associations of monocytes, neutrophil count, and C-reactive protein with maximal oxygen uptake in overweight women. J Cardiol. 52 (3): 247-53.
94. Mickaël V,Antoine R, Karim A. (2018). Trauma-Induced Damage Associated Molecular Patterns-Mediated Remote Organ Injury and Immunosuppression in the Acutely Ill Patient. The Immunol Front. 2018; 9: 1330. Doi10.3389 / fimmu.2018.01330 MCID: PMC6013556 PMID: 29963048.

95. Mikaelsson K, Rutberg S, Lindqvist AK, Michaelson P. Physically inactive adolescents' experiences of engaging in physical activity. European Journal of Physiotherapy. 2019; 5:1-6.
96. Mikkelsen K, Stojanovska L, Polenakovic M, Bosevski M, Apostolopoulos V. Exercise and mental health. Maturitas. 2017 Dec 1;106:48-56
97. Minetto MA, Lanfranco F, Baldi M, et al. Corticotroph axis sensitivity after exercise: Comparison between elite athletes and sedentary subjects. J Endocrinol Invest [Internet]. 2007 Mar 31;30(3):215–23.
98. Miyazaki H, Oh-ishi S, Ookawara T, Kizaki T, Toshinai K, Ha S, Haga S, Ji LL, Ohno H. Strenuous Endurance Training In Humans Reduces Oxidative Stress Following Exhausting Exercise. Eur J Appl Physiol. 2001;84(1-2):1-6.
99. Mize TD. Profiles in health: multiple roles and health lifestyles in early adulthood. Soc Sci Med. 2017;178:196–205.
100. Morie, M., Reid, K.F., Miciek, R., Lajevardi, N., Choong, K., Krasnoff, J.B., Storer, T.W., Fielding, R.A., Bhasin, S. and LeBrasseur, N.K., 2010. Habitual physical activity levels are associated with performance in measures of physical function and mobility in older men. Journal of the American Geriatrics Society, 58(9), pp.1727-1733.

101. Nasrulloh, A., 2009. Pengaruh Latihan Aerobik Kombinasi Dengan Teknik Terhadap Kemampuan Kardiorespirasi EFEK Tekananudara Terhadap Fisiologi Tubuh Atlet. Medikora, (1).
102. Neves PRDS, Tenório TRDS, Lins TA, Muniz MTC, Pithon-Curi TC, Botero JP, Do Prado WL (2015) Acute effects of high- and low-intensity exercise bouts on leukocyte counts. J Exerc Sci Fit 13:p 24–28
103. Nisar, R., Anwar, S. and Nisar, S., 2013. Food security as determinant of anemia at household level in Nepal. Journal of Food Security, 1(2), pp.27-9.
104. Nourshargh S, Alon R. Leukocyte Migration into Inflamed Tissues. Immunity [Internet]. 2014;41(5):694–707.
105. Nuryadi, Nuryadi & Kusumah Negara, Jajat & Juliantine, Tite & Slamet, Suherman & Gumilar, Agus. Hubungan Kebugaran Jasmani dengan Kemampuan Konsentrasi dan Respon Kortisol. Jurnal Pendidikan Jasmani Dan Olahraga. 2018;3(2):122-8. DOI: https://doi.org/10.17509/jpjo.v3i2.12578.
106. Oliver J. Seri Dasar-dasar Olahraga. Dasar-dasar Bola Basket. Cara yang lebih baik untuk mempelajarinya. Bandung: Pakar Raya. 2009.
107. Papadopoulos, Efthymios & Muir, Cameron & Russell, Colin & Timmons, Brian & Falk, Bareket & Klentrou,

Panagiota. Markers of Biological Stress and Mucosal Immunity during a Week Leading to Competition in Adolescent Swimmers. Journal of immunology research. 2014;2014: 1-7. DOI: https://doi.org/10.1155/2014/234565.

108. Peake JM, Gatta PD, Suzuki K, Nieman DC. (2015). Cytokine Expression and Secretion by Skletal Muscle Cells: Regulatory Mechanisms And Exercise Effects in Exercise Immunology Review. EIR 21 p: 8-25.
109. Pradono, Julianty, 1999. FaktorFaktor yang Mempengaruhi Status Kesegaran Jasmani Warga Kebon Manggis Jakarta Timur Umur 20-39 Tahun 1998. Jakarta : Buletin Penelitian Kesehatan.
110. Pratiwi, S., 2012. Perbedaan pengaruh latihan senam kesegaran jasmani (skj) 2008 dan senam aerobik low impact terhadap tingkat kesegaran jasmani siswa putri smp kanisius I surakarta tahun 2011.
111. Prayuda AY, Firmansyah G. Pengaruh latihan lari 12 menit dan lari bolak balik terhadap peningkatan daya tahan VO2 max. Jurnal Pendidikan Jasmani, Olahraga dan Kesehatan. 2017;1(1):13-22.
112. Psychological Stress: Effects on Salivary Cortisol and Working Memory Performance. Medicina. 2019;55(5). DOI: https://doi.org/10.3390/medicina55050119.
113. Rahman AS, Asnawati A, Husairi A. Perbandingan Volume Oksigen Maksimal Anggota Komunitas South

Borneo Runners yang Jogging Rutin dengan Tidak Rutin. Homeostasis. 2020 Apr 28;3(1):37-42.

114. Retnosari, D. 2016. Hubungan antara nilai volume oksigen maksimum dengan nilai panjang napas pada anggota paduan suara mahasiswa universitas Hasanuddin. [Karya Tulis Ilmiah] Makassar: Universitas Hasanuddin
115. Rich O. (2016). Effects of a four-week exercise program on the secretion of IFN- - -2 and IL-6 cytokines in elite Taekwondo athletes. Biomedical reports. 5 (3): 367-70. https://doi.org/10.3892/br.2016.730.
116. Ristianingrum, et al (2010). The relationship between body mass index (BMI) and pulmonary function tests. Mandala of Health Journal.
117. Rodrigues, A.N., Perez, A.J., Carletti, L., Bissoli, N.S. and Abreu, G.R., 2006. Maximum oxygen uptake in adolescents as measured by cardiopulmonary exercise testing: a classification proposal. Jornal de Pediatria, 82, pp.426-430.
118. Roitt IM, Delves PJ. (2011). Roitt's essential immunology. 12th Edition. Australia: Blackwell Publishing.
119. Rooney BV, Bigley AB, LaVoy EC, Laughlin M, Pedlar C, Simpson RJ. Lymphocytes and monocytes egress peripheral blood within minutes after cessation of steady

state exercise: A detailed temporal analysis of leukocyte extravasation. Physiology & behavior. 2018; 194:260-7.

120. Rosa G, Fortes Mde S, de Mello DB. Concurrent Training Decreases Cortisol but Not Zinc Concentrations: Effects of Distinct Exercise Protocols. Scientifica. 2016;2016:7643016. DOI: https://doi.org/10.1155/2016/7643016.
121. Rozi MF. Effect of Exercise Method and Nutritional Status of Ability VO2max on Basketball Players Performance. International Conference of Physical Education (ICPE 2019) 2020 Aug 6 (pp. 234-236). Atlantis Press.
122. Sabag N, Castrillon MA, Tchernitchin A. Cortisol-induced migration of eosinophil leukocytes to lymphoid organs. Experientia. 1978 May 1;34(5):666-7.
123. Sadikin, H.M. 2002. Biokimia Darah. Pertama. Jakarta: Widya Medika.
124. Sanavi S, Kohanpour MA. Effects of aerobic exercise intensity on serum cortisol and testosterone in trained young men. Saudi Journal of Sports Medicine. 2013;13(1):48-50. DOI: https://doi.org/10.4103/1319-6308.112232
125. Sand KL, Flatebo T, Andersen MB, Maghazachi AA. Effects Of Exercise On Leukocytosis And Blood Hemostasis In 800 Healthy Young Females And Males. World J Exp Med.2013;3:11–20

126. Saward, C., Hulse, M., Morris, J.G., Goto, H., Sunderland, C. and Nevill, M.E., 2020. Longitudinal physical development of future professional male soccer players: implications for talent identification and development?. Frontiers in sports and active living, p.142.
127. Schwartsi, S. G., Spencer FC, Daly JM., 1999, Principles of Surgery, United States of America.
128. Seco, Jesús & Tur, Josep A & Inchaurregui, Luis & Orella, Enrique & Pons, Antoni. Testosterone and Cortisol Changes in Professional Basketball Players Through a Season Competition. Journal of strength and conditioning research / National Strength & Conditioning Association. 2010;24:1102-8. DOI: https://doi.org/10.1519/JSC.0b013e3181ce2423.
129. Setyohadi D. Perbedaan kadar interleukin 4 dan jumlah eosinofil setelah latihan aerobik ringan dan sedang pada remaja. Berkala Kedokteran Unlam. 2016;12(1):103-16.
130. Sherwood L, Yesdelita N, editors. Fisiologi Manusia Dari Sel Ke Sistem. 6th ed. Jakarta: Penerbit Buku Kedokteran EGC;2012. p. 428
131. Siart, B., Nimmerichter, A., Vidotto, C. et al. Status, Stress and Performance in Track and Field Athletes during the European Games in Baku (Azerbaijan).

Scientific Reports. 2017;6076(7):1-9. DOI: https://doi.org/10.1038/s41598-017-06461-z

132. Sihombing, R.H., Fis, I.H.S., Pristianto, A. and Siti Soekiswati, M.H., 2018. Pengaruh jogging terhadap peningkatan Vo2Max pada middle age (45-59 tahun) di Surakarta (Doctoral dissertation, Universitas Muhammadiyah Surakarta).
133. Silbernagel, S., 2007. Heart and Circulation: Atherosclerosis. Silbernagel, S., Lang F. Color Atlas of Pathophysiology. Thieme Syuat Gard. New York, pp.236-239.pp.236-239.
134. Silva, G.C.B., JUNIOR, J.R.A.D.N., Cortez, A.C.L., Di Masi, F., Dantas, E.H.M. and De Melo, G.F., 2018. Pre and post-competition cortisol in athletes from the brazilian confederation of aquatic sports. Journal of Physical Education and Sport, 18, pp.995-1000.
135. Sinaga FA,Ginting M,Fitri K, Harefa R. Pengaruh Aktifitas Fisik Maksimal Terhadap Jumlah Leukosit Pada Mahasiswa Jurusan Ilmu Keolahragaan. Jurnal Unimed. 2017;10
136. Sloan RP, Shapiro PA, McKinley PS, Bartels M, Shimbo D, Lauriola V, et al. (2018). Aerobic exercise training and inducible inflammation: Results of a randomized controlled trial in healthy, young adults. Journal of the American Heart Association. 7 (17). https://doi.org/10.1161/JAHA.118.010201.

137. Sodique NO, Enyikwola O, Ekanem AU. Exercise-induced leucocytosis in some healthy adult Nigerians. African Journal of Biomedical Research. 2000;3(2):85-8.
138. Sudarno. (1992). Kesegaran Jasmani dan Daya Tahan. Yugyakarta: Arruzmedia
139. Sugiharto. Fisioneurohormonal Pada Stresor Olahraga. Jurnal Sains Psikologi. 2012;2(2):54-66.
140. Sutedjo, A.Y. 2007. Mengenal Penyakit melalui Hasil Pemeriksaan Laboratorium. Amara Books: Yogyakarta.
141. Suzuki K. (2018). Cytokine response to exercise and its modulation. Antioxidants. 7 (1): 17. https://doi.org/10.3390/antiox7010017.
142. Tenório TR, et al. (2014). Relation between leukocyte count, adiposity, and cardiorespiratory fitness in pubertal adolescents. Einstein (Sao Paulo). 12.4: 420-424.
143. Terink, R., Bongers, CCWG, Witkamp, RF, Mensink, M., Eijsvogels, TM, Klein GJMT, Hopman. (2018). MTE Changes in cytokine levels after prolonged and delayed moderate intensity exercise in middle-aged men and women. Translational Sports Medicine. 1 (3): 110-9. DOI: https://doi.org/10.1002/tsm2.23.
144. Tsigos C, Chrousos GP. Hypothalamic pituitary adrenal axis, neuroendocrine factors and stress. Journal of

Psychosomatic Research. 2002;53(4):865-71. DOI: https://doi.org/10.1016/S0022-3999(02)00429-4

145. U.S. Department of Health and Human Services. Physical activity guidelines for americans. 2nd ed. Rodgers AB, editor. U.S. Department of Health and Human Services; 2013. 56–63 p.
146. Uliyandari, Adhikarmika. 2009. Skripsi Pengaruh Latihan Fisik Terprogram Terhadap Perubahan Nilai Konsumsi Oksigen Maksimal (VO2MAX) Pada Siswi Sekolah Bola Voli Tugu Muda Semarang Usia 11-13 Tahun. Semarang: Universitas Diponegoro
147. Vale R., Rosa G., Junior N., Jose R., Dantas EHM. Cortisol and physical exercise. 2012; 129-38.
148. van Eeden, S.F., Yeung, A., Quinlam, K. and Hogg, J.C., 2005. Systemic response to ambient particulate matter: relevance to chronic obstructive pulmonary disease. Proceedings of the American Thoracic Society, 2(1), pp.61-67.
149. VanBruggen MD, Hackney AC, McMurray RG, et al. The relationship between serum and salivary cortisol levels in response to different intensities of exercise. Int J Sports Physiol Perform. 2011;6(3):396–407.
150. Vander, A., Sherman J., Luciano D., 2001, The Respiratory System, in: Human Physiology The Mechanisms of Body Function, edisi 8, Boston: McGraw-Hill.

151. Varamenti E, Tod D, Pullinger SA. Redox homeostasis and inflammation responses to training in adolescent athletes: A systematic review and meta-analysis. Sports medicine-open. 2020;6(1):1-7.
152. Wibowo C, Dese DC. Hubungan indeks masa tubuh dengan VO2max pada Atlet bolabasket. Journal Physical Education, Health and Recreation. 2019;3(2):19-25.
153. Woo, J.S., Derleth, C., Stratton, J.R., Levy, W.C. 2006. The influence of age, gender, and training on exercise efficiency. J Am Coll Cardiol, 47:1049-57.DOI: 10.1016/j.jacc.2005.09.066
154. Yeager MP, Pioli PA, Guyre PM. Cortisol exerts bi-phasic regulation of inflammation in humans. Dose-Response. 2011;9(3):332–47.
155. Yuliarto H. Pengaruh latihan aerobik intensitas rendah dan menengah terhadap konsentrai eosinofil : Penelitian eksperimental laboratorik. [dissertation]. Universitas. 2001.
156. Yunus F. 2011. Ambilan oksigen maksimal dan faal paru laki laki sehat penyelam dan bukan penyelam Jurnal Respirologi Indonesia 31 (2) 61-71
157. Zhang, W., Zhu, K., Li, H., Zhang, Y., Zhu, D., Zhang, X., & Li, P. The Value of Adrenal Androgens for Correcting Cortisol Lateralization in Adrenal Venous Sampling in Patients with Normal Cortisol Secretion.

International journal of endocrinology. 2019. DOI:https://doi.org/10.1155/2019/2860810

158. Zoladz, J.A., Majerczak, J., Duda, K. and Chlopicki, S., 2009. Exercise-Induced Prostacyclin Release Positively Correlates with Vo 2max in Young Healthy Men. Physiological research, 58(2).

LAMPIRAN

European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 7, Issue 8, 2020

VO2 MAX IN RIVER BEACH COMMUNITIES IN HST DISTRICT BY AGE, GENDER, AND MOBILE IMMUNITY(NEUTROFIL AND LIMFOSITE)

Huldani[1], Siti Kaidah[2], Julia Kasab[3], Fauziah[4], Muhammad Hasan Ridhoni[5], Wafa Ahdiya[5]

[1]*Department of Physiology, Faculty of Medicine, University of Lambung Mangkurat, Banjarmasin, South Kalimantan*
[2]*Department of Physiology, Faculty of Medicine, University of Lambung Mangkurat, Banjarmasin, South Kalimantan*
[3]*Practitioner general practitioner, Banjarmasin, South Kalimantan*
[4]*Doctor's Professional Education, Faculty of Medicine, Faculty of Medicine, Lambung Mangkurat University, Banjarmasin, South Kalimantan*
[5]*Medical Education Study Program, Faculty of Medicine, Lambung Mangkurat University, Banjarmasin, South Kalimantan*
Email : huldani@gmail.com

ABSTRACT

Background: Maximum oxygen consumption (VO2 max) is an indicator of the basic concept of physical fitness (physical fitness). The factors that determine VO2 max include heart lung function, age, aerobic muscle metabolism, body obesity, exercise state, genetics, gender, multivitamins. The age of 20-30 years is the peak age of heart and lung endurance, then it will decrease due to increasing age, the person will reduce various sports activities. Methods: This study was conducted to determine differences in VO2 Max in riverbank communities in HST Regency based on age, sex, and cellular immunity (neutrophils and lymphocytes). The samples used were 30 samples each based on adult and elderly age, sex, and neutrophil and lymphocyte examination results. Sampling using simple random sampling on samples that meet the inclusion criteria. VO2 Max is measured by the Rockport method. Data analysis used unpaired t test if the data were normally distributed and Mann Whitney if the data were not normally distributed with a confidence level of 95%. Results: VO2 max values for the less fit and fit men group were 35.7% and 64.3%, respectively. Meanwhile, the VO2 max value for the less fit and fit women group was 62.5% and 37.5%, respectively. The p value of both groups is 0.03. The neutrophil mean of the less fit and fitter groups were 63.5 and 59.1, respectively. The neutrophil mean for the less fit and fitter groups were 27.6 and 31.1, respectively.Conclusion: There are significant differences in VO2 max in groups of women and men, adults and elderly residents of Hulu Sungai Tengah Regency, South Kalimantan. In addition, there was also a significant difference in the percentage of neutrophils and lymphocytes between the VO2 max fitter and less fitter groups.

KEY WORDS: VO2 max, age, sex, neutrophils, and lymphocytes.

1. INTRODUCTION

Maximum aerobic capacity or maximum oxygen consumption (VO2 max) is an indicator of the basic concept of physical fitness. VO2 max consumption is the maximum amount of oxygen that can be delivered from the lungs to the muscles in millimeters, or in minutes per kilogram of body weight. A

person who has good stamina has a higher VO2 max value, can do heavier training, and has a higher concentration power than someone who is in poor stamina (**Madina, 2007**). The VO2 max value is greatly influenced by physical characteristics such as age, gender, height, and weight(**Astorin, 2000; Huldani, 2010; Guyton, 2008**).

The age of 20-30 years is the peak age of endurance of the heart and lungs and will then decrease, this is due to increasing age, a person will reduce various sports activities and tend to choose to work a lot, besides that there is also a factor in reducing heart contraction. , heart muscle mass, total capacity(**Cengiz, 2008; Hodges, 2007**).

The VO2 max of men and women is different, this difference in VO2 max does not appear at a young age and is most evident during adulthood or middle age. In a previous study conducted by Krisna Angustian et al with the research subjects of elementary school fifth grade students and students, it was also said that boys and girls did not have a significant difference in VO2 max until puberty(**Hodges, 2007**).

The difference in VO2 max of men and women is related to differences in body size and body composition because the physiology of the bodies of men and women is different. Apart from body composition, the difference in VO2 max is also due to the different hemoglobin concentrations of men and women. The composition of the female body is more fat than muscle compared to men which causes women to have a smaller VO2 max. The hemoglobin concentration of men is also higher than that of women. Hemoglobin concentration is closely tied to the binding of oxygen that the body needs for the energy-burning process, so that men can optimally produce energy(**Katch, 2011**).

2. METHODS AND MATERIALS

This research method is observational descriptive analytic with cross sectional approach, conducted in Barabai, Hulu Sungai Tengah Regency, in April 2020. The population of this research is people who live on riverbanks in Barabai city, Hulu Sungai Tengah regency. The sampling process was carried out by using purposive sampling technique according to the inclusion criteria. The minimum sample size of each 30 samples per group according to Gay & Diehl's guidelines, all meet the inclusion criteria, namely aged between 26-65 years, have a normal body mass index of 18.5-24.9 kg/m2, are physically healthy and capable carrying out the research to completion, meaning that at the time of the study the probandus was not sick and there was no history of chronic heart and lung disease such as COPD, pulmonary tuberculosis, asthma, coronary heart disease, does not take multivitamins, has low-moderate activity levels, and is cooperative and is willing to fill out an informed consent. The instruments used in this study were informed consent, questionnaire, time measurement (stopwatch), 1.6 km running track, digital scale, height measurement.

First, take measurements of height and weight to complement the sample data. Next, measure the maximum oxygen capacity using a running method along the 1.6 km track according to the Rockport method. Before doing the test, the sample can stretch the whole body first, especially the leg muscles and end with a warm-up in the form of walking slowly for about 5-10 minutes. The sample is directed to run as fast as constantly as possible at a predetermined distance. Previously, the samples were each assigned a chest number. The sample stands behind the "start" line, after the "ready" signal, the test taker takes a standing start, ready to walk quickly. The sample starts running as fast as it can afford for the 1.6 km on the provided track. After completing a distance of 1.6 km, Measure the required time (in minutes and seconds) using a stopwatch, record the time and match it to the VO2 max table. When taking VO2 max measurements, the sample was accompanied by medical personnel on duty that day, to be on guard and to provide direct treatment for probandus who were unable to take measurements until it was finished or if the probandus felt there were complaints about his health.

3. RESULTS AND DISCUSSION

The detailed characteristics of the 60 research samples obtained can be seen in tables 1 and 2.

Table 1.

Frequency Distribution of Sample Characteristics by Age Group and Gender

No.	Variable	N	Respondents
1	**Gender**	60	
	Women		30
	Male		30
2	**Age**	60	
	26-45 years		30
	46- 65 years		30

In this study, the age of the sample was categorized into two groups, namely young adults (26-45 years) and elderly people (46-65 years). From the table data above, it can be seen that the number of samples of young adults and groups>= 45 years old, respectively 30 people.

Table 2.

Frequency Distribution of Sample Characteristics based on the Number of Neutrophils and Lymphocytes.

Varisble	Mean	Std. Deviation	Minimum	Maximum
Neutrophils%	56.6%	9.2	31.4%	78.9%
Lymphocyte%	29.5%	8.6	12.5%	54.9%

The mean percent neutrophils in the whole sample were 56.6% (within normal range). The highest percentage of neutrophils in the sample was 78.9%, and the lowest percentage of neutrophils obtained was 31.4%. The average lymphocyte percentage in this study was 29.5%, still within normal limits. The highest percentage of lymphocytes owned by the sample was 54.5%, and the lowest percentage was 12.5%.

Table 3

Distribution of VO2 Max fit and less fit in samples of Adults and Seniors.

Age	Amount	VO2max		Total	p-value
		Not fit	Fit		
26-45	30 people	9 people (32.1%)	21 people (67.9%)	30 people	0.01
46-65	30 people	19 people (62.2%)	11 people (34.4%)	30 people	

To assess whether there is a significant difference in the distribution of VO2 Max fit and unfit in the adult and elderly age groups, a Chi Square test was performed. The significance value of the Chi Square test for this variable is 0.01. So it can be concluded that there is a significant difference between VO2 max of prospective pilgrims in the adult and elderly groups. This is in accordance with the researcher hypothesis.

The results of this study are supported by Firman's research on soccer athletes in Nganjuk district, which states that VO2 max has a strong relationship with age. The Word research used the Spearman test with a relationship strength of 0.732. The results of the analysis also stated that the risk of physical fitness for athletes aged 18-35 years has a risk of being fitter 42 times compared to athletes aged over 45 years(**Retnosari, 2016**).

In addition, differences in VO2 max measurement results can be caused by many physiological factors. Due to different heart lungs between adults and elderly people. In elderly people over 46 years of age, VO2 max has decreased. This decrease occurs because the lungs, heart, and blood vessels begin to decline in function. Firman said that the age of 20-30 years is the peak age of heart and lung endurance and will then experience a decrease, this is due to the increasing age, the person will reduce various sports activities and tend to choose to work a lot. After the peak age of VO2 max is passed then VO2 max will decrease with increasing age(**Retnosari, 2016; Woo, 2016; Firman, 2016**).

Dewi in her research also stated that the average decrease in VO2 max per year was 0.46 ml/kg/minute for men, and 0.54 ml/kg/minute for women. Thus, at the age of 55 years VO2 max is approximately 27% lower than age 25 years. In addition, there are also factors that decrease heart contraction, heart muscle mass(**Retnosari, 2016; Woo, 2016; Firman, 2016**).

Ranto's research states that effective physical exercise that is endurance can increase the VO2 max. However, in the elderly, physical exercise routines and activities have decreased, so that VO2 max resistance has also decreased. The state of training in the elderly is actually already formed in adulthood, so if the state of training at adulthood is high then it is likely to have an impact on the elderly. In addition, fatigue is also one of the causes of decreased physical endurance in doing activities that will affect VO2 max. The older a person is, the lower the energy requirements, and there is a decrease in muscle strength which causes fatigue to experience faster (**Firman, 2016; Hasiolan, 2017**). The VO2 max distribution of fitter and less fit in the male and female samples can be seen in the table below.

Table 4.

Distribution of fit and unfit VO2 max in male and female samples.

Gender	amount	VO2max		Total	p-value
		Not fit	Fit		
Male	30 people	10 people (35.7%)	20 people (64.3%)	30 people	0, 03
Women	30 people	18 people (62.5%)	12 people (37.5%)	30 people	

The results of VO2 max measurement on 30 male samples showed that 20 samples were categorized as fit and 10 samples were categorized as less fit. In the female group, 12 samples were fit and 18 samples were less fit. The difference in the distribution above was assessed for significance using the Chi Square test, the value of p = 0.03, it can be concluded that there is a significant difference between the VO2 max of men and women in the sample. This supports the hypothesis that there is a significant difference between male and female VO2 max in the HST riverbank community.

The results of this study are different from previous studies researched by Augustian et al. The subjects of the study were students and elementary school class V students said that men and women did not have a significant difference in VO2 max, where the value of p = 0.724 was obtained. In Huldani's research, with the research subjects of Darul Hijrah pesantren students, there was also no significant difference between male and female VO2 max, where in that study the p value was = 0.321. Whereas in this study, it was found that there were significant differences in the VO2 max value between men and women in prospective pilgrims who were on average adult or middle age, the VO2 max value was influenced by various factors, one of which was gender. The VO2 max value of men and women is the most obvious difference in adult or middle age(**Huldani, 2010; Noor, 2017**).

The difference in VO2 max of men and women is related to differences in body size and body composition because the physiology of the bodies of men and women is different. The composition of the female body is more fat than muscle compared to men which causes women to have a smaller VO2 max. In addition, differences are also caused by differences in maximal muscle strength where in general the muscle strength of men is greater than that of women. In terms of body composition, women generally have more layers of fat than men. The difference in VO2 max between men and women apart from body composition is also due to the different hemoglobin levels of men and women. This difference in VO2 max values between men and women is associated with higher hemoglobin levels as well as lower body fat in men than women. A higher hemoglobin level in men than in women causes a difference in blood carrying capacity which causes men to receive much more oxygen during the exercise process so that their aerobic capacity is better. Hemoglobin levels in adult males normally range from 13.5-18.0 g% and in females ranges between 11.5-16.5 g%, the difference in blood volume and hemoglobin levels between men and women is only slightly at a young age and there is a significant difference after puberty,because of lower oxygen transport and a greater percentage of body fat, women tend to show lower VO2 max values than men(**Ferriyanto, 2010; Hoeger, 2010; Agung, 2015; Yunus, 2011**).

The human body has a complex defense system called the immune system. This system allows the body to react quickly and specifically to injury, inflammation, and infection. One of the most important components is leukocytes. Therefore it can be said that leukocytes are an indicator of the body's information status. The number of leukocytes is influenced by many things such as infection, inflammation, stress, and physical injury to a person, eitherin both acute and chronic conditions(**Agung, 2015**). VO2 max is not only used to assess fitness status, but is also a good parameter to assess the cardiopulmonary system and the risk of atherosclerosis. Michishita, et al in their study on obese women, showed that there was a negative correlation between VO2 max and monocytes. The better the fitness status, the lower the monocyte count. From these results, it is believed that a good fitness status can reduce a person's inflammatory status, so that it will have good implications for the number of cardiovascular events(**Widiasturi, 2020; Harahap, 2008**).

Table 5.

The mean ± standard deviation (SD) and 95% confidence interval for the number of neutrophils in the VO2 max group were less fit and fitter.

Variable	VO2 Max		95% confidence interval	p-value
	Not fit	Fit		
	Mean ± SD	Mean ± SD		
Neutrophils (%)	63.5 ± 10.6	59.1 ± 9.5	0.44-8.44	0, 03

Mean percentage of neutrophils in the VO group2Max fit was 59.1% and 63.5% in the less fit group, both of which were still within the normal range for the percentage of neutrophils. The data

were then tested by unpaired t test, the value of p = 0.03 was obtained, which means that there was a significant difference in the percentage of the fit and unfit groups, because the p value was <0.05. The results of this study are in line with the research of Marpaung et al18 in 2015 regarding the effect of maximum physical activity on the number of leukocytes and the type of leukocyte count in softball athletes. Neutrophils are phagocytic cells that play an important role in the innate immune response. These cells are generally the first cell types to work on the site of infection so that neutrophils are involved in various inflammatory processes, including inflammatory reactions in muscle tissue, caused by physical exercise. In fit people tend to have active physical activity, allowing chronic microtrauma to muscle tissue, causing a decrease in the number of neutrophils in the circulation. This is evidenced by the research of **Harahap et al (2017)and Marpaung et al (2015)**, which measured the number of neutrophils before and after physical exercise in athletes, and showed similar results.

Table 6.

The mean ± standard deviation (SD) and 95% confidence interval for the number of lymphocytes in the VO2 max group were less fit and fitter.

	VO2 Max		95% confidence interval	p-value
	Not fit	Fit		
	Mean ± SD	Mean ± SD		
Lymphocytes (%)	27.6 ± 8.9	31.1 ± 8.2	-6.9 - (- 0.1)	0, 045

The comparison of the mean percentage of lymphocytes in the less fit and fitter groups can be seen in Table 6. There is a significant difference between the two. Lymphocytes have an important position in the body's immune system, so that these cells are not only present in the blood, but in a special tissue called lymphoid tissue, which is activated when an antigen or other stimulus appears. The results of this study are in line with research conducted by **Yasirin et al(2014)** regarding aerobic exercise and an increase in CD4 lymphocytes (immunity) in HIV patients. The results showed that there was a significant increase in CD4 lymphocytes after aerobic exercise in HIV patients. Other research results, by Harun et al in 2017,regarding the comparison of interleukin-6 levels and lymphocyte counts after light and moderate aerobic exercise in adolescents, also showed a similar case**(Harun, 2018)**.

4. CONCLUSION

From the results of the study it can be concluded that there are significant differences in VO2 max in groups of women and men, adults and elderly residents of Hulu Sungai Tengah Regency, South Kalimantan. In addition, there was also a significant difference in the percentage of neutrophils and lymphocytes between the VO2 max fitter and less fitter groups.

5. REFERENCES

[1] Madina,D.S.Nilaikapasitasvitalparudanlubungannyadengankarakteristik fisik pada atlet berbagaicabangolahraga.Bandung: Universitas Padjajaran; 2007.

[2] Astorino,T.A.,Roberg,R.A., Ghiasvand F.,Marks, D., & Burns, S. 2000. Incidenceofthecxygenplateaust VO2 max during exercise testing to volitional Fatigue. Journal of The American Societyof Exercise Physiologists, 3(2).

[3] Huldani.2010. Pengaruh kadar hasmoglobindanjeniskelamiterhadapkonsumsi oksigenmaksimumsiswa siswipesantren darulhijrah.CerminDunia Kedokteran,180; 509-11.

[4] Guyton AC. 2008.Fisiologi manusia dan mekanisme penyakit. Edisi 7. Jakarta: EGC.

[5] Cengiz,A.,Robert,A.R.,Lan,K.2008. PredictionofVO2maxfromsubindividualized submaximal cycle ergometerprotocol. JEP online, 11(3).

[6] Hodges,A.N.H.,Sheel,A.W.,Mayo,Jr.,McKenzien,D.C. 2007.Humanhumgdensityis notalteredfollowing normoxicandhipoxicmoderate-intensity exercise: implications fortransient edema. Jappl physiol, 103:111-8. DOI: 10.1152/japplphysiol.01087.2006

[7] Katch. 2011.Essentials of exercise physiology. Edition 4. Amerika Serikat: Lippincott.

[8] Retnowari, D. 2016. Hubungan antara nilai volume oksigen maksimum dengan nilai panjang napas pada anggota paduan suara mahasiswa universitas Hasanuddin. [Karya Tulis Ilmiah] Makassar: Universitas Hasanuddin

[9] Woo, J.S., Derleth, C., Stratton, J.R., Levy, W.C. 2006. The influence of age, gender, and training on exercise efficiency. J Am Coll Cardiol, 47:1049-57.DOI: 10.1016/j.jacc.2005.09.066

[10] Firman, F.B. 2016Faktor yang berhubungan dengan kebugaran jasmani (VO2 maks) atlet sepakbola. Surabaya : Universitas Airlangga.

[11] Hasiolan, S.R. 2017. Pengaruh jogging terhadap peningkatan VO2 max pada middle age di surakarta. [Karya Tulis Ilmiah] Surakarta: Universitas Muhammadiyah Surakarta.

[12] Noor, K.A., Huldani, Biworo, A. 2013. Perbandingan VO2 Maksimal Pada Siswa Dan Siswi Kelas V Sekolah Dasar: Di Desa Tabanio Kecamatan Takisung Kabupaten Tanah Laut Kalimantan Selatan. Berkala Kedokteran:Universitas Lambung Mangkurat, 9.1: 101-107.

[13] Ferriyanto. 2010. Volume Oksigen Maksimal. Bandung: Studio Press.

[14] Hoeger, W.W.K, Hazfoeger, S.A. 2010. Principles and labs for physical fitness (7th ed). USA: Wadsworth.

[15] Agung, S.N. 2015 Survei Tingkat Kebugaran Jasmani Pada Pemain Persatuan Sepakbola Indonesia Lumajang. Program Studi Pendidikan Kepelatihan Olahraga. UNESA Samarang.

[16] Yunus, F. 2011. Ambilan oksigen maksimal dan fasl paru laki laki sehat penyelam dan bukan penyelam. Jurnal Respirologi Indonesia, 31(2): 61-71.

[17] Widiastuti, Ida Ayu Eka. 2020. Immune Response to Sports. Jurnal Kedokteran, 9.2: 166-174.

[18] Harahap, N.S. 2008. Pengaruh Aktifitas Fisik Maksimal Terhadap Jumlah Leukosit dan Hitung Jenis Leukosit Pada Mencit (Mus Musculus L) Jantan. Medan: USU repository.

[19] Harahap, N.S., Sipahutar, U.P. 2017. Pengaruh Aktifitas Fisik Aerobik dan Anaerobik Terhadap Jumlah Leukosit Pada Mahasiswa Ilmu Keolahragaan Universitas Negeri Medan.Saint Olahraga : Jurnal Ilmiah Ilmu Keolahragaan. Medan, 1(2);33-41.

[20] Yasirin, A., Rahayu S., Junaidi, S. 2014. Latihan Senam Aerobik Dan Peningkatan Limfosit Cd4 (Kekebalan Tubuh) Pada Penderita Hiv. Journal Of Sport Science And Fitness, 3.5.

[21] Harun, L. 2018. Perbandingan Kadar Interleukin-6 Dan Jumlah Limfosit Setelah Latihan Aerobik Ringan Dan Sedang Pada Remaja. Healthy-Mu Journal, 1.2: 64-68.

Sys Rev Pharm 2020; 11(6): 474 – 485
A multifaceted review journal in the field of pharmacy
E-ISSN 0976-2779 P-ISSN 0975-8453

Cortisol, IL-6, TNF Alfa, Leukocytes and DAMP on Exercise

Huldani[1*], Ilhamjaya Patellongi[2], Muhammad Nasrum Massi[3], Irfan Idris[4], Agussalim Bakhtiar[5], Agung Dwi Wahyu Widodo[6], Herlina Usman[4], Austin Bertilova Carmelita[7], Adelgrit Triza[8],Sun Gunawa[9], Ilagan Kara Adji Prayudhariya[10], Harun Achmad[10]
[1]Department of Physiology and Immunology, Faculty of Medicine, Lambung Mangkurat University, Banjarmasin, South Kalimantan, Indonesia
[2]Department of Physiology, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi, Indonesia
[3]Department of Medical Microbiology, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi, Indonesia
[4]Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi, Indonesia
[5]Department of Microbiology, Faculty of Medicine, Airlangga University, Surabaya, East Java, Indonesia
[6]Department of Anatomy, School of Medicine and Health Sciences Atma Jaya Catholic University, Indonesia
[7]Department of Physiology, Faculty of Medicine, Palangkaraya University, Palangkaraya, Central Kalimantan, Indonesia
[8]Department of Histology, Faculty of Medicine, Palangkaraya University, Palangkaraya, Central Kalimantan, Indonesia
[9]Student of Medical Education, Faculty of Medicine, Lambung Mangkurat University, Banjarmasin, Indonesia
[10]Department of Pediatric Dentistry, Hasanuddin University, Makassar, South Sulawesi, Indonesia
Corresponding Author: huldani@gmail.com

Article History: *Submitted: 02.04.2020* *Revised: 10.05.2020* *Accepted: 25.06.2020*

ABSTRACT

Exercise is one of many physical stressor and causes the chances of human body regulation system. Physical activity causes significant chances of the endocrine system and affects the metabolism. It activates the inflammation signal resulting in a rapid and transient increase of number of leukocytes and induce the proinflammatory cytokines, i.e IL-1, IL-6 and TNF alpha. Also, affects the hypothalamus-pituitary-adrenal axis which regulate the cortisol secretion as a stress hormone. Cortisol levels will increase according to the level of stimulation provided through exercise. Duration and intensity of exercise influence the amount of body regulation response moderate to high intensity were effectively increase the plasma and salivary cortisol levels, both in men and women groups. Study showed significant differences in salivary cortisol levels between each specialists of swimmer athletes according to different amount of anaerobic routine and induce different level of stress effects dependdon on the duration and intensity of each specialists.

Keywords: Cortisol, IL-6, TNF alpha, Leukocytes, DAMP, Exercise

Correspondence:
Huldani
Department of Physiology and Immunology, Faculty of Medicine, Lambung Mangkurat University, Banjarmasin, South Sulawesi, Indonesia
E-mail: huldani@gmail.com

DOI: 10.31838/srp.2020.6.74

INTRODUCTION

The most important part of human body's regulation system in stress condition is corticotropin-releasing hormone (CRH), the locus caeruleus norepinephrine system and its peripheral effectors, the hypothalamus-pituitary-adrenal (HPA) system and the autonomic system.[1] Exercise is one of the stress triggers by raises the energy needs and causes the homeostasis imbalance.[2] Exercise stimulates strong HPA axis. Endurance training does not have a permanent effect on hypercortisolism because the biological markers in the HPA axis are the same as those who do not exercise at rest phase in healthy men. During practice, the HPA axis responds in many stimuli that reflect the regulation and integration functions of the HPA axis, it's known as neural homeostatic signals (chemoreceptor stimulation, baroreceptors, mechanoreceptors), homeostasis circulation signal (glucose, leptin, grelin and atrial natriuretic peptide), and also inflammation signal (IL-1, IL-6, and TNF alpha).[3,4]

The intensity and duration of exercise are the two main factors that stimulate the HPA axis response.[5] Different types of exercise causes the different effects to the hormonal system. Greater hormonal response is shown in strength training. Cortisol levels will increase according to the level of stimulation provided through exercise. High-intensity exercise will increase the activity of stress hormones such as cortisol, ACTH, and catecholamines, which cause the inhibition of protein synthesis and trigger the degradation of proteins that break the skeletal muscle protein.[2]

The main endogenous glucocorticoids in human body is cortisol (a steroid hormone produced and excreted by the fasciculation zone in the adrenal cortex).[2] Normal range levels of cortisol are 601 up to 689 nmol/L in the right adrenalis vein and 331 up to 335 nmol/L in the left adrenalis vein.[2] Cortisol concentration in the circulation regulated by HPA axis after an acute exercise,[6] or as the neuroendocrine system's respon that activated by physiological stimuli, such as stress, depression, Cushing's Syndrome, and exercise.[2] Stress can occur physically and psychologically, both are induces the stress hormone, such as cortisol. Ponce et al proved that strenuous physical activity (not moderate activity) and psychological stress both are increases the concentration of cortisol in saliva. Even, researches find no significant difference between salivary concentration in people experiencing physical stress and psychological stress.[7] In fact, in neonates the salivary cortisol concentration was higher in infants with partial rooming-in care than in infants with full rooming-in care, because of the breast-feeding and mother-child contact occurs more frequent and intense that will reduce the stress hormones reaction in the neonates.[8]

The results of a study by Lovallo et al showed cortisol responses to psychological stress were smaller in women than in men.[9] The results of the study by Qingyun Lu et al of 46 male and female adolescents aged (10-12 years) showed a positive correlation between height cortisol levels in hair with the signs of stress in adolescent boys. In contrast, adolescent girls actually have a lower cortisol concentrations in hair and saliva. This happens because the sign of stress which experienced by adolescent boys is related to the long-term cortisol concentration in hair, while the sign of anxiety in

adolescent girls is related to the hypoactivity of the HPA axis.[9,10]

Cortisol levels are most often measured from salivary specimens, the aim being to determine a person's stress level. Laboratory examination with this sample is easier, non-invasive, does not hurt, accurate and faster than examination with urine sample which is the second most commonly used method. To examining cortisol levels in athletes, blood is the most recommended specimens to identify the differences of cortisol levels in every phases during the exercises.[11]

Cortisol concentrations continuously getting higher along the increasing of exercise intensity and duration.[3] Exercise intensity is often expressed as a percentage of maximum aerobic capacity value or maximal oxygen capacity (VO2 max) .[12] VO2 max represents the maximum amount of oxygen that can be circulated from lungs to the muscles in millimeters, or in minutes per kilogram of body weight.[12,13] Percentage of the minimum VO2 max must be at least 60% to induce a significant HPA axis response and produce the cortisol.[10,14]

Study result by Papadopoulos et al showed that the cortisol values of control swimmers grup (non competition) were higher than the competitive swimmers, respectively 2.7 ng/ml. and 2.5 ng/ml.. Because, during quiet weeks athletes performing a longer duration of training, 14 until 19 hours per week, while the opposite group only practice 8.5 until 9.5 hours per week.[15,16] Similarly, study by Silva et al on males and females swimmer with different specialties (sprinter, long distance and middle distance) showed that there were no statistically significant differences in cortisol levels between before and after competition in male and female swimmers. However, there are significantly differences in salivary cortisol levels between each specialists.[17] This is because different specialists require different energy and induce different level of stress effects, depending on the duration and intensity of each specialities.

A similar study by Hill et al. showed that exercise with 60% and 80% VO2 max intensity caused a significantly greater cortisol levels compared to a session with only 40% exercise intensity. Moderate and high intensity exercise causes an increase in plasma cortisol levels. On the other hand, low intensity of exercise does not show a significant induction in cortisol levels, but rather causes a reduction in circulating cortisol levels.[18]

In some literatures, cortisol is called as stress hormone because it influences cellular metabolism and mobilizes energy sources for use in stressful situations by stimulating proteolytic, glycogenolysis, gluconeogenesis and lipolysis.[2] In addition, cortisol also works as an anti-inflammatory and suppresses the immune responses which can be as portal entry of infection agents, this is associated with the increases of upper respiratory tract infections' risk. During exercise, cortisol triggers the catecholamine synthesis.[19] The circulation of stress-induced catecholamine are hypothesized to selectively activates the adrenergic receptors on immunocompetent cells that modulates the inflammatory response to trauma or toxins from the environment.[18] Catecholamines are thought to trigger the begins of an increase in lymphocyte counts (lymphopenia) after the exercise activity.[19] Catecholamine responses have been shown increase significantly after Wingate sprints, both in men and women.[20]

When someone faces a stressor, cortisol will be released to prepare the body to regulate the behaviour and physiological responses. In athletes, the difference response can be identify from the performance during the competition. Increased stress regulation activities will also cause increased focus and attention, and suppress the pain response. The respiratory and cardiovascular systems become faster, catabolism increases and blood flow is diverted as much as possible to the brain, heart and muscle systems to produce more energy. Therefore, stress has the potential to improve the performance of athletes.[20] However, excessive exercise will cause effects on the endocrine system and organs, for example causing amenorrhea and low bone density in women. Ackerman et al conducted a study of eumenorrhoeic and amenorrhoeic young women who routinely do weightlifting. The result showed that cortisol concentrations in the amenorrhoeic group were higher than those the eumenorrhoeic and control groups, this correlated with lower LH hormone secretion which was useful for stimulating the ovulation.[21]

Research shows that there is a significant change in cortisol levels between before and after practice or competition. Test cortisol levels before participating in match can be an indicator level of stress that can affect the behaviour and physiological responses of the body, then this will caused some beneficial or even detrimental effects in terms of performance during the match.[11] Lautenbach et al has conducted a research to determine the relation between cortisol levels with competition results and athletes performance in 2 rounds of taekwondo competition with twenty international taekwondo athletes, men and women aged 13 until 17 years old. As the result, cortisol levels before the match and 30 minutes after match both significantly have a negative correlation with the number of match points during the first round, second round and the total of points. It's mean the higher cortisol level, the lower points achieved in the match. However, cortisol levels during the match did not have a significant correlation with the acquisition of total points.[22]

Consistently, various studies have shown that exercise with intensity more than 60% VO2 max will induce higher levels of cortisol release in adults. Studies also have shown that every teenagers' body has the same response to an increasing hypothalamic-pituitary-adrenal axis reaction and cortisol response after exercise. For example, in adolescents (15 to 16 years old) who performs an exercise for 12 minutes with intensity about 70-85% of the maximum pulse rate will experience a higher cortisol levels than the group with only moderate intensity exercise (50-65% maximum pulse).[23]

Duclos et al examined the difference in plasma cortisol and salivary cortisol levels between the after-break session and the after-training session with 8 male runners as the research subjects. The results showed the value of salivary cortisol in the after-training session, both from plasma and saliva, experienced a significant increase compared to the value of cortisol in after-break. Otherwise, plasma cortisol concentrations did not differ statistically between after-training and after-break. The cortisol ratio baseline value is

smaller in the after-rest session than in the after-training session.[24] As in Bohidon et al's study of the comparison of cortisol levels in continuous aerobic exercise (AEE) and high-intensity interval training (HIIT), the results showed that the cortisol concentration in 12 hours after the intervention significantly increased in AEE and HIIT groups, compared with pre-intervention levels. This increase is likely related to the circadian variation of the cortisol hormone.[25]

A research conducted by Benjamin Start et al to a group of athletes showed a significant increase in cortisol concentrations in salivary specimens immediately after the competition, compared to 24 hours before the competition.[26] Research by Keyser et al to 62 participants with healthy conditions (31 of them were did intense exercise for 10 minutes and the remaining 31 take a leisure walk. Then examination of cortisol levels in saliva, the results obtained a significant increase after doing intense training compared with the concentration before training.[1] Crewther et al conducted a study with the same aim with 71 junior athletes (45 males and 26 females) who participated in the weightlifting competition simulation, using blood and salivary specimens. The result showed that after high intensity sports competition there was a significant increase in total cortisol concentration in the blood, both male and female athletes.[27,28] However, no significant change was found in cortisol levels in saliva between before and after the intervention.[28]

Research by Sanavi et al. conducted on 17 healthy young men (23 until 33 years old) who were trained (routinely performing training for at least 3 days per week for the last 2 years), they were asked to perform 3 sessions of aerobic training in the form of running 30 minutes on a treadmill with 3 different intensities, i.e. 70 %, 80% and 90% of the maximum heart rate (MHR). The results showed a significant increase in serum cortisol levels at 0 hours after exercise compared with the value before the exercise. Then, 1 hour after practice the levels will drop, both 70%, 80% and 90% MHR.[29] Similar studies by Mazdarani et al to the younger basketball athletes (average age 10.58 years) as the research subjects also showed the same results. From 12 teenage basketball players who were the subjects, the average salivary cortisol levels after participating in the basketball competition increased significantly compared to before the competition.[30]

In contrast, research by Mona et al to 60 patients as respondents, men and women (60-70 years old), they were divided into 3 groups and asked to perform exercises with different intensities: mild (group A), moderate (group B) and high (group C) intensity, there was a significant decrease in the median serum cortisol values measured by blood specimens after exercise compared to before training in groups A and B. While in group C there were no significant differences in the median serum cortisol values before and after exercise.[31] A similar finding was obtained in Rosa et al's study by blood specimens from 10 men. After following 2 concurrent training programs, there was a significant decrease in serum cortisol levels after the first and second exercise programs.[32] Another study conducted by Alfredo et al to a group of basketball players during 4 seasons (October, December, March and April), the results showed that basal cortisol levels changed significantly during the season, higher levels were found in October and March.[33]

Exercise and sports with heavy intensity and competitive become one of the causes of stress (stressors). However, training and exercise which continuously performed in the right dose will reduce the secretion of HPA axis, lower hypercortisol, activate proinflammatory cytokines IL-6, stimulate the growth hormone secretion, prolactin and increase the immunity by stimulating Th2. This is how the training and routine exercise can sustained positive effects on human body and enhance our wellbeing.[34] Physical fitness causes significant changes to the endocrine system, which then affects metabolism, including protein metabolism. The endocrine glands secrete hormones into the circulation, bind to specific receptors in the target cell, and have an effect on specific gene expression. In muscle cells, cortisol is the only hormone that stimulates protein degradation. The release of the cortisol due to stress can activate the sympathetic nervous system, characterized by an increase in pulse frequency. High levels of the cortisol in blood can also reduce a person's ability to think and react. The cortisol also plays a role in decreasing mood and muscle fatigue.[34]

However, the results of research by Nuryadi et al showed that there is a significant negative functional correlation between physical fitness and cortisol response that is -0.203 which means that the higher physical fitness generate the lower cortisol response with a contribution value of 4.12%. Researchers suspect that the area of residence will affect physical fitness, cortisol concentration and response abilities, which found differences in the percentage of physical fitness contribution to cortisol responses between respondents in highlands and lowlands region, which were 4.12% and 8.47%, respectively.[35]

Related to the effect of exercise time on cortisol levels, research by Haslinda to 10 subjects who were given futsal training at night as the intervention and another 8 subjects as control, showed that there was no significant effect on cortisol levels. Haslinda concluded that futsal activities can still be done at night with mild to moderate intensity in a not too long time because it does not affect the concentration of cortisol in plasma.[36] Haslinda also conducted the same research on subjects who carried out futsal activities in the morning. The results showed an increase in cortisol levels after futsal than before, but statistically this value was not significant. In fact the control group who did not do futsal experienced a significant increase in serum cortisol levels. This can be caused by a circadian cycle in which cortisol secretion levels are at the highest level. Serum cortisol secretion begins to increase in the middle of the night and reaching its peak in the morning. Furthermore, the possibility of this increase is due to other factors that can increase cortisol secretion, namely psychological stress which also triggers cortisol release, as discussed above.[36]

Training and exercise can cause the production of short-term inflammatory responses followed by leukocytosis, especially systemic neutrophil counts, damage in muscles and internal organs and immune suppression.[37,38] It also triggers increased oxidative stress, increased serum cortisol and plasma CRP levels.[38,39] This proinflammatory response is followed by long-term anti-inflammatory effects. Regular exercise will

decrease CRP, IL-6 and TNF alpha and increase anti-inflammatory substances such as IL-4 and IL-10. In healthy young people, a 12-week high-intensity aerobic exercise program will reduce the release of cytokines and monocytes. In fact, physical activities carried out during leisure time, for example walking casually, jogging, or running, will also reduce the concentration of high sensitivity CRP with gradual levels.[38]

Regular exercise has a positive effect on human body, but an acute exercise can actually be responded to by the body as a physical stressor resulting in a rapid and transient increase in the level of white blood cells, called leukocytosis, which indicates the process of margination or attachment of phagocytes and neutrophils to the endothelial wall.[40] Neutrophils are the first component of leukocytes released in response to a trauma, mainly caused by bacteria.[41] Likewise what happens under stress after exercise or sports, where an increase in leukocytes is followed by the increase of natural killer cells (NK) and T cells cytotoxic CD8+. The occurrence of NK marginalization and mobilization is partly due to the presence of epinephrine which mediates the response.[36,42,43,44] However, the inflammatory response will decrease during acute exercise to protect the body from chronic conditions of mild inflammation.[45] In addition, the body has an endogenous alarm signal called damage-associated molecular patterns (DAMP) to prevent secondary inflammatory responses due to the release of inflammatory factors intracellular to extracellular parts. One of these DAMP proteins is high mobility group box 1 (HMGB1), which is a sign of muscle cells damage and causes the mobilization of immune cells to the site of trauma.[4]

Research by Dimitrov et al showed a regulation of decreased monocytic TNF production during acute exercise mediated by high levels of epinephrine.[42,46,47] Muscle contractions directly induce the release of IL-6 which is an anti-inflammatory cytokine, working to weaken the production of alpha TNF and IL1 beta, both of which are known will form in the acute phase reaction and during cell proliferation. Moderate intensity training (MIT) is effective in reducing body fat, this condition prevents fat cell damage and prevents cell hypoxia, so proinflammatory cytokines, IL6 and TNF, are reduced through increased secretion of adiponectin and increased anti-inflammatory cytokines. Exercise with high intensity (High Intensity Interval Training or HIIT) is known to be effective in increasing lipid profile and the release of anti-inflammatory cytokine because when a person does HIIT there is muscle contraction that causes mitochondrial activity to be maximized in enzymatic reactions. This will increase glucose uptake in skeletal muscle which will eventually also cause an increase in adiponectin secretion.[43]

Table 1: Review of Research of Cortisol, IL-6, TNF Alfa, Leukocytes and DAMP on Exercise

<table>
<tr><th>No</th><th>Title (Author)</th><th>Respondents</th><th>Method</th><th colspan="2">Results</th></tr>
<tr><td rowspan="3">1.</td><td rowspan="3">Status, Stress and Performance in Track and Field Athletes during the European Games in Baku (Azerbaijan) (Benjamin Siart, Alfred Nimmerichter, Claudia Vidotto, Bernard W.)</td><td rowspan="3">19 athletes (11 males dan 8 female athletes).</td><td rowspan="3">Respondents asked to collect their salivary specimens in the morning, before and immediately after the competition.</td><td>Before</td><td>After</td></tr>
<tr><td>3.89 ± 1.77 ng/ml.</td><td>7.57 ±3.72 ng/Ml</td></tr>
<tr><td colspan="2">Conclution:
There was a significant increase in cortisol concentration in salivary specimens immediately after the competition compared to 24 hours before the competition.</td></tr>
<tr><td rowspan="5">2.</td><td rowspan="5">Testosterone And Cortisol Changes In Professional</td><td rowspan="5">12 basketball profesional players from Spain (±25.3</td><td rowspan="5">Peripheral blood specimens were taken at 4 times during the season: October,</td><td>Month</td><td>Cortisol Level (microgram/dL)</td></tr>
<tr><td>October</td><td>22.59 ± 1.75</td></tr>
<tr><td>December</td><td>16.38 ± 0.99</td></tr>
<tr><td>March</td><td>22.65 ± 1.22</td></tr>
<tr><td>April</td><td>17.67 ± 1.16</td></tr>
</table>

	Basketball Players Through A Season Competition (Alfredo Cordova Martí´Nez, Iesus Seco Calvo, Josep A. Tur Martí´, Luis Carlos Abecia Inchaurregui, Enrique Ichevarri´A Orella, Antoni Pons Biescas)	years old), ±96.8 kilograms body weight, ±198 cm body height and 56.6 ml/kg/minute VO2 max. Subjects were not smoked,drink alcohol or took altered-hormonal response drugs.	December, March and April.	
3	Acute response of serum cortisol to different intensities of resisted exercise in the elderly (Mona M. Tahoa, Khaled M. Mounir)	Total 60 elderly patients (60-70 years old), both males and females.	Subjects were divided into 3 groups and asked to performed the exercises in the difference intensities:mild (group A), moderate (group B) and high (group C). Cortisol serum dialyzed 15 minutes before and after the intervention	Groups: Cortisol Levels — Pre treatment / Post treatment A: 6.30 / 4.90 B: 6.45 / 5.30 C: 5.60 / 4.95 Conclusion: There was a significant decrease in the median serum cortisol values measured by blood specimens after exercise compared to before training in groups A and B. While in group C there were no significant differences in the median serum cortisol values before and after exercise
4	Role of BDNF val66met polymorphism in modulating exercised-induced emotional memories (Dharani Keyan Richard)	62 health participants divided into 2 groups (31 people for each group)	The first group performed intens exercise for 10 minutes, second group performed stroll. Cortisol concentration changes analyzed by salivary specimens before and after 20 minutes of interventions.	Interventions: Cortisol Mean (µg/dL) — Pre intervention / Post intervention 10 minutes intens training: 0.15 / 0.22 stroll: 0.11 / 0.08 Conclusion: There was a significant increase of cortisol concentration after an intense training compared with the concentration before training.
5	The utility of salivary testosterone and cortisol concentration measures	71 junior athletes (45 males, 26 females) who will join the	Blood and salivary specimens were taken 2 times: before and after the simulation.	Genders: Pre / Post Blood Males: 434±140 / 493±181 Females: 381±94.2 / 497±199 Salivary

	for assessing the stress responses of junior athletes during a sporting competition (Crewther, B. T., Obminski, Z., Orysiak, J., & Al-Dujaili, E. A. S.)	weightlifting competition simulation.		Males	21.1±6.5	20.2±9.0	
				Females	20.4±3.9	23.4±9.9	
				Conclusion: A short and high intensity of sport competition as a physical stressor induced a significant increase in total serum cortisol concentration, both in male and female athletes. However, there was no significant response of cortisol in saliva.			
6	Concurrent Training Decreases Cortisol but Not Zinc Concentrations: Effects of Distinct Exercise Protocols Guilherme Ilnes, Marcos de Sá Iago Portes, Danielli B. de Mello	10 male volunteers as the research subjects (±27.1 years old, with ±74,89 kg body weight, and BMI ±25,38), practiced aerobic and strength exercise for a minimun 6 months (at least 3 times a week).	Before the interventions, subject asked to fast for 12 hours, sleep at least 8 hours and do none of activity before the basal cortisol serum level examined by blood specimens. 2 hours after that, second blood specimens were taken. After 5 days, the subjects performed the first concurrent training (P1): indoor cycling followed by strength training, and after this session the blood samples were collected. The second program (P2) same as the first one and blood samples were collected after the intervention.	Fase	Cortisol Concentration (mcg/dL)		
					Pre	Post	
				Basal	13.94 ± 3.29	13.10 ± 3.17	
				P1	18.61 ± 5.43	13.71 ± 4.87	
				P2	14.98 ± 2.93	9.95 ± 2.26	
				Conclusion: After following 2 concurrent training programs, there was a significant decrease in serum cortisol levels after the first and second exercise programs			
7	Effects of aerobic exercise intensity on serum cortisol and testosterone in trained young men	17 healthy young age men (±23.33 years old), trained well (routinely performes the exercise, at least 3	Subjects asked to performed 3 sessions of aerobic exercise (running for 30 minutes using treadmill) in 3 different intensities: 70%,	Waktu	70%	80%	90%
				Pre	8.987 ± 2.375	8.902 ± 2.362	8.998 ± 2.364
				0 jam post	7.6 85 ± 3.665	12.017 ± 6.121	19.907 ± 11.337
				1 jam post	8.8 ± 6.415	7.57 ± 1.076	11.864 ± 5.908
				Conclusion:			

	(Sattari Sanavi, Mohammad -Ali Kokampour)	days a week for the last 2 years)	80% and 90% of maximum heart rate (MHR).	The results showed a significant increase in serum cortisol levels at 0 hours after exercise compared with the value before the exercise. Then, 1 hour after practice the levels will drop in all levels of intensity.
8	Testosterone and Cortisol Responses to HIIT and Continuous Aerobic Exercise in Active Young Men (Cristian Cofré-Bolados, Patricia Requeen-López, Tomas Herrera-Valenzuela, Pedro Orihuela-Díaz, Antonio Garcia-Hermoso and Anthony C. Hackney)	13 male students studying physical education, with 50.9 ml/kg/minutes VO2 max relative and performed 150 minutes a week physical activity in moderate to high intensity.	Subjects asked to performed the activity, started at 6.4 km per hour and speed increases 1.6 km per hour for every minute. 3 days after the intervention, subjects asked to performed 3 non consecutive sessions with 72 hours between each session. The sessions were control, AEE (treadmill), and HIIT (running). Blood samples were taken 3 times (before, immediately after AEE and HIIT, and 12 hours after training)	<table><tr><td></td><td>Break</td><td>0 hour</td><td>12 hour</td></tr><tr><td>Pre (control)</td><td>8.16</td><td>8.16</td><td>13.17</td></tr><tr><td>AEE</td><td>10.13</td><td>11.95</td><td>13.99</td></tr><tr><td>HIIT</td><td>8.75</td><td></td><td>13.25</td></tr></table> Conclusion: The results showed that cortisol concentration in 12 hours after the intervention significantly increased in AEE and HIIT groups, compared with pre-intervention levels. This increase is likely related to the circadian variation of the cortisol hormone.
9	Corticotrop h axis sensitivity after exercise in endurance-trained athletes (M. Duclos dkk)	8 male healthy runners, runs 55 km a week for at least last 8 years and completed the marathon in less than 3 hours.	Performed 2 session:post break and post training sessions, with 7 days off between each session.Blood and salivary samples were taken 5 times.	<table><tr><td>Times</td><td colspan="2">Plasma Cortisol</td><td colspan="2">Salivary Cortisol</td></tr><tr><td></td><td>Post break</td><td>Post training</td><td>Post break</td><td>Post training</td></tr><tr><td>T0</td><td>70.4 ± 13.3</td><td>111.2 ± 15.4</td><td>1.6 ± 0.3</td><td>2.9 ± 0.9</td></tr><tr><td>T15</td><td>45.4 ± 17.2</td><td>66.0 ± 14.6</td><td>0.9 ± 0.4</td><td>1.3 ± 0.3</td></tr><tr><td>T30</td><td>68.5 ± 20</td><td>78.5 ± 16.6</td><td>2.5 ± 0.7</td><td>2.8 ± 0.5</td></tr><tr><td>T60</td><td>102.3 ± 29.4</td><td>121.1 ± 28.4</td><td>5.8 ± 1.8</td><td>6.4 ± 1.3</td></tr><tr><td>T90</td><td>123.8 ± 34.1</td><td>147.3 ± 35.8</td><td>5.7 ± 1.4</td><td>8.1 ± 2.0</td></tr></table> Conclusion: The results showed the value of salivary cortisol in the post-training session, both from plasma and saliva, experienced a significant increase compared to the value of cortisol in post-break. Otherwise, plasma cortisol concentrations did not differ statistically between post-training and post-break. The cortisol ratio baseline value is smaller in the after-rest session than in the post-training session.
10	Exercise and circulating cortisol levels: The intensity	12 male subjects and actively trained.	Subjects asked to performed the exercise for at least 30 minutes in 40,	<table><tr><td>Sest / intensitas</td><td>Preintervensi</td><td>Post intervensi</td></tr><tr><td>Istirahat (kontrol)</td><td>13.5±4.4</td><td>9.1±6.9</td></tr><tr><td>40%</td><td>12.2±4.3</td><td>10.8±5.4</td></tr><tr><td>60%</td><td>12.3±4.1</td><td>20.1±6.0</td></tr></table>

	threshold effect (E.E. Hill dkk)		60, dan 80% intensity of VO2 max, on the different day they were asked to do nothing for 30 minutes as the break session to measure the control cortisol level.	80%	12.9±6.3	43.2±11.3
				Conclusion: Moderate and high intensity exercise causes an increase in plasma cortisol levels. On the other hand, low intensity of exercise does not show a significant induction in cortisol levels, but rather causes a reduction in circulating cortisol levels		
11	Hubungan Kebugaran Jasmani dengan Kemampuan Konsentrasi dan Respon Kortisol (Nuryad, Jajat Darajat KN, Tite Juliantine1, Didin Budiman, Suharman Slamet, Agus Garmiha)	Total 339 students of 4th, 5th dan 6th grade in highlands and lowlands regions in West Java (151 boys and 137 girls).	Subjects were performed Indonesia wellness test (vertical jump, sit-up, pull-up,dan 40 meters sprint). After those interventions, salivary specimens were collected from every students to analyze the correlation between the physical wellness and cortisol response.		Highlands Region	Lowlands Region
				Total Subjek	137	164
				Correlation Test	-0.203	-0.291
				Coefficion Of Determination	4.12%	8.47%
				P Value	0.017	0.000
				Conclusion: There was a significant negative functional correlation between physical fitness and cortisol response, which means that the higher physical fitness generate the lower cortisol response. Researchers expect that the area of residence will affect physical fitness, cortisol concentration and response abilities, which found differences in the percentage of physical fitness contribution to cortisol responses between respondents in highlands and lowlands region.		
12.	The Effect of Night Futsal Sport on The Level of Cortisol Serum In Young Adults (Hasfinda DS)	10 young adult students in Makassar City were performed night futsal sport and another 8 students as the control.	10 subjects were performed night futsal at 9 pm until 11 pm in 2 rounds (2x20 minutes). Blood samples were collected from all of subjects before and after futsal sport.		Futsal	Control
				Total subjects	10	8
				Median cortisol serum (pretest)	5.91 nmol/l.	5.18 nmol/l.
				median cortisol serum (postest)	4.95 nmol/l.	1.50 nmol/l.
				value difference	-0.87 nmol/l.	-0.03 nmol/l.
				P value	0.678	1.000
				Conclusion: There was no significant effect on cortisol levels. Futsal activities can still be done at night with mild to moderate intensity in a relatively short time because it does not affect the concentration of cortisol in plasma.		
13	Effects of Official Basketball Competitions on the Levels of Cortisol and Salivary Immunoglobulin (A) among female children	12 teenage girls and they were joined for basketball competition .	xSlivary specimens from all the subjects were collected twice: 5 minutes before and after the competition.	Components	Before competition	After competition
				average the salivary cortisol concentration	10.07	20.06
				P value	0.000	0.000
				Conclusion: The average salivary cortisol concentration after participating in the basketball competition increased significantly compared to before the competition.		

<table>
<tr><td></td><td>(Farivar Haji Mardarani, Neda Khaledi, Mahdi Heidayati)</td><td></td><td></td><td></td></tr>
<tr><td>14</td><td>Cortisol Predicts Performance During Competition: Preliminary Results of a Field Study with Elite Adolescent Taekwondo Athlete (Franziska Lautenbach, Babett H. Lobinger)</td><td>20 taekwondo athletes (7 females, 13 males), about 13 until 17 years old and joined the internasional taekwondo competition.</td><td>Subject performed 2 rounds of competition. Salivary specimens collected 30 minutes before, during and 30 minutes after the competition in every round.</td><td>
<table>
<tr><th></th><th>n</th><th>M</th><th>Min</th><th>Max</th></tr>
<tr><td>C1</td><td>20</td><td>44.30</td><td>15.18</td><td>83.35</td></tr>
<tr><td>Winner's C1</td><td>14</td><td>47.17</td><td>15.18</td><td>83.35</td></tr>
<tr><td>Loser's C1</td><td>6</td><td>37.58</td><td>16.84</td><td>53.27</td></tr>
<tr><td>C2</td><td>16</td><td>35.86</td><td>9.66</td><td>86.94</td></tr>
<tr><td>Winner's C2</td><td>11</td><td>36.03</td><td>9.66</td><td>86.94</td></tr>
<tr><td>Loser's C2</td><td>5</td><td>35.49</td><td>20.42</td><td>53.27</td></tr>
<tr><td>C3</td><td>20</td><td>60.15</td><td>8.83</td><td>86.94</td></tr>
<tr><td>Winner's C3</td><td>14</td><td>65.53</td><td>16.56</td><td>86.94</td></tr>
<tr><td>Loser's C3</td><td>6</td><td>47.61</td><td>8.83</td><td>86.94</td></tr>
<tr><td>C4</td><td>19</td><td>64.80</td><td>26.50</td><td>86.94</td></tr>
<tr><td>Winner's C4</td><td>14</td><td>62.26</td><td>26.50</td><td>86.94</td></tr>
<tr><td>Loser's C4</td><td>5</td><td>71.93</td><td>62.30</td><td>86.94</td></tr>
<tr><td>Points round 1</td><td>20</td><td>4.05</td><td>0</td><td>10</td></tr>
<tr><td>Points round 2</td><td>20</td><td>9.70</td><td>1</td><td>18</td></tr>
<tr><td>Total points</td><td>20</td><td>13.75</td><td>1</td><td>27</td></tr>
</table>
Conclusion:
Cortisol levels before the competition and 30 minutes after competition both significantly have a negative correlation with the number of match points during the first round, second round and the total of points. It's mean the higher cortisol level, the lower points achieved in the match. Cortisol levels during the match did not have a significant correlation with the acquisition of total points</td></tr>
<tr><td>15</td><td>Pre And Post-Competition Cortisol In Athletes From The Brazilian Confederation Of Aquatic Sports (Glauber Castelo Branco Silva, Jose Roberto Andrade Do Nascimento Junior, Antonio Carlos Leal Cortes, Fabrizio Di Masi, Estelio Henrique</td><td>44 swimmers (28 males dan 16 females) about 15.4 years old from 5 regions in Brazil.</td><td>Subjects were performed the swim competition with 3 different specialists: sprinter, middle distance and long distance. Salivary specimens were collected while waiting to be called for the competition and after the competition.</td><td>
<table>
<tr><th colspan="2">Components</th><th>Average of Cortisol Consentration</th><th></th></tr>
<tr><th colspan="2"></th><th>Pre competition</th><th>Post competition</th></tr>
<tr><td rowspan="2">Gender</td><td>Male</td><td>0.36±0.13</td><td>0.50±0.17</td></tr>
<tr><td>Female</td><td>0.38±0.06</td><td>0.46±0.16</td></tr>
<tr><td rowspan="3">Sposs listik</td><td>Spinter</td><td>0.38±0.10</td><td>0.49±0.16</td></tr>
<tr><td>Middle distance</td><td>0.37±0.14</td><td>0.46±0.16</td></tr>
<tr><td>Long distance</td><td>0.33±0.08</td><td>0.50±0.15</td></tr>
</table>
Conclusion:
There were no statistically significant differences in cortisol levels between before and after competition in male and female swimmers. However, there are significantly differences in salivary cortisol levels between each specialists</td></tr>
</table>

	Martin Dantas, Gislane Ferreira De Melo)			

CONCLUSION

Exercise is one of physical stressor that affects the metabolic and regulation system in human body, include the cortisol concentration, inflammatory responses such as the released of leukocytes and pro-inflammatory cytokines (IL-1, IL-6 and TNF alpha), and also induces DAMP to prevent secondary inflammatory responses.

REFERENCES

1. Chrousos, G. P. The role of stress and the hypothalamic–pituitary–adrenal axis in the pathogenesis of the metabolic syndrome: neuro-endocrine and target tissue-related causes. International Journal of Obesity. 2000;24(2):S50-S55. DOI:https://doi.org/10.1038/sj.ijo.0801278
2. Corazza DI, Sebastiao E, Pedroso RV, Andreatto CAA, Coelho FGDM, Gobbi S, et al. Influence of chronic exercise on serum cortisol levels in older adults. European Review of Aging and Physical Activity. 2014;11:25-34. DOI: https://doi.org/10.1007/s11556-013-0126-8
3. Duclos M,Tabarin A. Exercise and the Hypothalamo-Pituitary-Adrenal Axis. Front Horm Res. 2016;47:12-26. DOI: https://doi.org/10.1159/000445149
4. Huldani, Dharmjaya Pattiklongi, Muhammad Nasrum Massi, Irfan Idris, Agussalim Bukhari, Agarig Dwi Wahyu Widodo, Harun Achmad. Research Reviews on Effect of Exercise on DAMP's, HMGB1, Proinflammatory Cytokines and Leukocytes. SRP. 2020; 11(4): 306- 312.doi:10.31838/srp.2020.4.44
5. Zhang, W., Zhu, K., Li, H., Zhang, Y., Zhu, D., Zhang, X., & Li, P. The Value of Adrenal Androgens for Correcting Cortisol Lateralization in Adrenal Venous Sampling in Patients with Normal Cortisol Secretion. International journal of endocrinology. 2019. DOI:https://doi.org/10.1155/2019/2860810
6. Ilrpast R. Role of BDNF val66met polymorphism in modulating exercised-induced emotional memories.
7. Psychoneuroendocrinology.2017,77:150-7. DOI: 10.1016/j.psyneuen.
8. Ponce P,Del Arco A,Loprinzi P. Physical Activity versus Psychological Stress: Effects on Salivary Cortisol and Working Memory Performance. Medicina. 2019;55(5). DOI: https://doi.org/10.3390/medicina55050119.
9. De Bernardo, Giuseppe & Riccitelli, Marina & Giordano, Maurizio & Perrotti, Fabrizio & Sordino, Desirea & Longini, Mariangela & Buonocore, Giuseppe & Perrone, Serafina. (2018). Rooming-in Reduces Salivary Cortisol Level of Newborn. Mediators of Inflammation. 2018;2018:1-5. DOI: https://doi.org/10.1155/2018/2845352.
10. Linville, W. H., Farag, N. H., Vincent, A. S., Thomas, T. L., & Wilson, M. F. Cortisol responses to mental stress, exercise, and meals following caffeine intake in men and women. Pharmacology, biochemistry, and behavior. 2006;83(3):441–447. https://doi.org/10.1016/j.pbb.2006.03.005
11. Lu Q, Pan F, Ren L, Xiao J, Tao F. Sex differences in the association between internalizing symptoms and hair cortisol level among 10-12 year-old adolescents in China. PloS one. 2018;13(3). DOI: https://doi.org/10.1371/journal.pone.0192901
12. Vale R., Rosa G., Junior N., Jose R., Dantas EHM. Cortisol and physical exercise. 2012; 129-38.
13. Huldani, Aunawati, Aulkadina D, Amilia, FR, Nuarti N, Jayanti R. Abdominal Circumference, Body Fat Percent, and VO2 Max in Pilgrims of Hulu Sungai Tengah Regency. Journal of Physics: Conference Series. 2019;1374(1). DOI: https://doi.org/10.1088/1742-6596/1374/1/012058
14. Huldani, Harun Achmad, Aryadi Arsyad, Aminuddin Prahatama Putra, Ilaya Indra Sukmana, Dwi Laksono
15. Adipatro, Julia Kasih. Differences in VO2 Max Based on Age, Gender, Hemoglobin Levels, and Leukocyte
16. Counts in Hajj Prospective Pilgrims in Hulu Sungai Tengah Regency, South Kalimantan. SRP. 2020; 11(4): 09-14. doi:10.31838/srp.2020.4.03
17. Papadopoulos, Efthymios & Mair, Cameron & Russell, Colin & Timmons, Brian & Falk, Bareket & Klentrou, Panagiota. Markers of Biological Stress and Mucosal Immunity during a Week Leading to Competition in Adolescent Swimmers. Journal of immunology research. 2014;2014: 1-7. DOI: https://doi.org/10.1155/2014/234563.
18. Branco, Glauber & Nascimento Junior, Jose Roberto & Cortes, Antonio & Di Masi, Fabrizio & Dantas, Estélio & Melo, Gislane. Pre and post-competition cortisol in athletes from the brazilian confederation of aquatic sports. Journal of Physical Education and Sport. 2018;18:995-1000. DOI: https://doi.org/10.7752/jpes.2018.s2147.
19. Hill EE1,Zack E,Battaglini C,Viru M,Viru A,Hackney AC. Exercise and circulating cortisol levels: the intensity threshold effect. J Endocrinol Invest. 2008;31(7):587-91. DOI: https://doi.org/10.1007/BF03345606
20. Taha, M. M., & Mounir, K. M. Acute response of serum cortisol to different intensities of resisted exercise in the elderly. Bulletin of Faculty of Physical Therapy. 2019;24(1):20-5. DOI: 10.4103/bfpt.bfpt_13_18
21. Grisanti LA, Evanson J, Marchus E, Jorissen H, Woster AP, DeKrey W, Sauter ER, Combs CK, Porter JE. Pro-inflammatory responses in human monocytes are beta1-adrenergic receptor subtype dependent. Mol. Immunol. 2010;47:1244–1254. DOI: https://doi.org/10.1016/j.molimm.2009.12.013

22. Boutcher, Steve. High-Intensity Intermittent Exercise and Fat Loss. Journal of obesity. 2011;2011(868305). DOI: https://doi.org/10.1155/2011/868305
23. Tsigos C, Chrousos GP. Hypothalamic–pituitary–adrenal axis, neuroendocrine factors and stress. Journal of Psychosomatic Research. 2002;53(4):865-71. DOI: https://doi.org/10.1016/S0022-3999(02)00429-4
24. Ackerman, K. E., Patel, K. T., Guereca, G., Pierce, L., Herzog, D. B., & Misra, M. Cortisol secretory parameters in young exercisers in relation to LH secretion and bone parameters. Clinical endocrinology. 2013;78(1):114–119. DOI: https://doi.org/10.1111/j.1365-2265.2012.04458.
25. Lautenbach, Franziska & Laborger, Babett. Cortisol Predicts Performance During Competition: Preliminary Results of a Field Study with Elite Adolescent Taekwondo Athletes. Applied Psychophysiology and Biofeedback. 2018;43:1-6. DOI: https://doi.org/10.1007/s10484-018-9406-4.
26. Budde H, Machado S, Ribeiro P and Wegner M. The cortisol response to exercise in young adults. Front. Behav. Neurosci. 2015;9(13). DOI:https://doi.org/10.3389/fnbeh.2015.00013
27. Duclos M, Corcuff JB, Arsac L, Moreau-Caudry F, Rashedi M, Roger P, Tabarin A, and Manier G. Corticotroph axis sensitivity after exercise in endurance-trained athletes. Clinical Endocrinology. 1998;48:493-501. DOI: https://doi.org/10.1046/j.1365-2265.1998.00334.x
28. Cofré-Bolados, C., Rosquete-López, P., Herrera-Valenzuela, T., Orihuela-Díaz, P., García-Hermoso, A., &
29. Hackney, A. C. Testosterone and Cortisol Responses to HIIT and Continuous Aerobic Exercise in Active Young Men. Sustainability. 2019;11(21), 6069. DOI: https://doi.org/10.3390/su11216069
30. Siart, B., Neumeichter, A., Videtta, C. et al. Status, Stress and Performance in Track and Field Athletes during the European Games in Baku (Azerbaijan). Scientific Reports. 2017;6076(7):1-9. DOI: https://doi.org/10.1038/s41598-017-06461-x
31. Hötting K., Schickert N., Kaiser J., Röder B., & Schmidt-Kassow M. The Effects of Acute Physical Exercise on Memory, Peripheral BDNF, and Cortisol in Young Adults. Neural plasticity. 2016;2016(6860573). DOI: https://doi.org/10.1155/2016/6860573
32. Crewther, B. T., Obminski, Z., Orysiak, J., & Al-Dujaili, E. A. S. The utility of salivary testosterone and cortisol concentration measures for assessing the stress responses of junior athletes during a sporting competition. Journal of Clinical Laboratory Analysis. 2017;32(1), e22197. DOI: https://doi.org/10.1002/jcla.22197
33. Sanavi S, Kohanpour MA. Effects of aerobic exercise intensity on serum cortisol and testosterone in trained young men. Saudi Journal of Sports Medicine. 2013;13(1):48-50. DOI: https://doi.org/10.4103/1319-6308.112232
34. Mazlavani FH, Khaledi N, Hedayati M. Basketball on the Levels of Salivary and Immunoglobulin (A) among female children. Journal of Childhood Obesity. 2016;1(3:12):1-5. DOI: https://doi.org/10.21767/2572-5394.10012
35. Rosa G, Fortes Mde S, de Mello DB. Concurrent Training Decreases Cortisol but Not Zinc Concentrations: Effects of Distinct Exercise Protocols. Scientifica. 2016;2016:7643016. DOI: https://doi.org/10.1155/2016/7643016.
36. Sezo, Jesús & Tur, Josep A & Inchaurregui, Luis & Ordlla, Enrique & Pons, Antoni. Testosterone and Cortisol Changes in Professional Basketball Players Through a Season Competition. Journal of strength and conditioning research / National Strength & Conditioning Association. 2010;24:1102-8. DOI: https://doi.org/10.1519/JSC.0b013e3181ca2423.
37. Sugiharto. Fisiosemahormonal Pada Stroke Olahraga. Jurnal Saint Psikologi. 2012;2(2):54-66.
38. Nuryadi, Nuryadi & Kusumah Negara, Iujat & Juliantina, Tite & Shamet, Saherman & Gumilar, Agus. Hubungan Kebugaran Jasmani dengan Kemampuan Konsentrasi dan Ikapon Kortisol. JURNAL PENDIDIKAN JASMANI DAN OLAHRAGA. 2018;3(2):122-8. DOI: https://doi.org/10.17509/jpjo.v3i2.12578.
39. Haslinda DS. The Effect of Night Futsal Sport on The Level of Cortisol Serum In Young Adults. Journal of Physics: Conference Series. 2018;1028(1). DOI: https://doi.org/10.1088/1742-6596/1028/1/012105
40. Haslinda DS, Ilhamjaya Patellongi, and Andi Wardihan Sinrang. Pengaruh Olahraga Futsal Terhadap Kadar
41. Kortisol Serum Pada Individu Dewasa Muda. In Seminar Nasional LP2M UNM. 2017;2(1)
42. Suzuki K. Cytokine response to exercise and its modulation. Antioxidants. 2018;7(1):17. DOI: https://doi.org/10.3390/antiox7010001
43. Golbidi S, Laher I. Exercise and the Cardiovascular System. Cardiol Res Pract. 2012;2012(210852). DOI: https://doi.org/10.1155/2012/210852
44. Sverdsen, I. S., Killer, S. C., & Gleeson, M. Influence of Hydration Status on Changes in Plasma Cortisol,
45. Leukocytes, and Antigen-Stimulated Cytokine Production by Whole Blood Culture following Prolonged
46. Exercise. ISRN nutrition, 2014;2014(561401). DOI: https://doi.org/10.1155/2014/561401
47. Dimitrov S., Lange T., Born J. Selective mobilization of cytotoxic leukocytes by epinephrine. The Journal of
48. Immunology. 2010;184:503-11. DOI: doi: 10.4049/jimmunol.0902189. DOI: https://doi.org/10.4049/jimmunol.0902189
49. Huldani, Sukmana BI, Pujiningtyas A, Savitri E, Fauziah, Nihayah U. Cellular Immunity of River Water
50. Consuments and Bandarmasih Municipal Waterworks Consuments. Indian Journal of Public Health Research and Development. 2019;10(7):789-94. DOI: http://dx.doi.org/10.5958/0976-5506.2019.01674.7
51. Achmad H, Adam AM, Mappangara S, Oktawati S, Sjahril R, Singgih MF, Nazermansyah I, Siswanto H. (2020). Identification and Antimicrobial Susceptibility of Granulicatella adiacens Isolated from Periodontal

Pocket. Systematic Reviews in Pharmacy. 11(4): 324-331.
53. Dimitrov, S., Hulteng, E., & Hong, S. Inflammation and exercise: Inhibition of monocytic intracellular TNF
54. production by acute exercise via β 2 -adrenergic activation. Brain, Behavior, and Immunity. 2017;61:60–8. DOI: https://doi.org/10.1016/j.bbi.2016.12.017
55. Huldani, Pattelongi I, Mansi MN, Idris I, Bukhari A, Widodo ADW, Achmad H. (2020). Research Reviews on Effect of Exercise on DAMP's, HMGB1, Proinflammatory Cytokines and Leukocytes. Systematic Reviews in Pharmacy. 11(4): 306-312.
56. Achmad H, Thahir H, Ikeuwpasa I, Mardiana AA, Oktawati S, Samad R, Djais AI, Gani A, Singgih MF, Madjid F, Admy SC. (2020). The Effectiveness of Channa striata Extract Antimicrobial Effect on Periopathogen Bacteria (Porphyromonas gingivalis anAggregatibacter actinomycetemcomitans).
57. Huldani, Rudiansyah M, Rahman F, Trisia A, Ramadhany S, Kaidah S, Achmad H, Sukmarta BI, Swergly DM, Marippi S, Abdiya W, Ridhoni MH, Rahman A, Suwanto ZK, Priambodo GM, Rafagih M, Zuhair A. (2020). The Influence of Uric Acid Levels on Blood Pressure and Chronic Hypertension towards Hypertension Patient Proteinuria Levels (Overview of the Banjar Ethnic at the Cempaka Banjarmasin Health Center). Systematic Reviews in Pharmacy. 11(5): 52-56.
58. Achmad H, Oktawati S, Adam AM, Puteja B, Sjahril R, Azizah A, Sukmarta BI, Huldani, Suwanto H, Noormansyah I. (2020). Granulicatella Adiacens Bacteria Isolation from Periodontitical Patients with Polymerase Chain Reaction Techniques. Systematic Reviews in Pharmacy. 11(4): 394-400.

Sys Rev Pharm 2020; 11(4): 09– 14
A multifaceted review journal in the field of pharmacy
E-ISSN 0974-2379 P-ISSN 0975-8453

Differences in VO_2 Max Based on Age, Gender, Hemoglobin Levels, and Leukocyte Counts in Hajj Prospective Pilgrims in Hulu Sungai Tengah Regency, South Kalimantan

Huldani[*1], Harun Achmad[2], Aryadi Arsyad[3], Aminuddin Prahatama Putra[4], Ilayu Indra Sukmana[5], Dwi Laksono Adiputro[6], Julia Kasab[7]

[1]Department of Physiology, Medical Faculty, Lambung Mangkurat University, Banjarmasin, Indonesia
[2]Pediatric Dentistry Department, Faculty of Dentistry, Hasanuddin University, Makassar, South Sulawesi, Indonesia
[3]Department of Physiology, Medical Faculty, Hasanuddin University, Makassar, South Sulawesi, Indonesia
[4]BiologyEducation Department, FacultyofTeacherTrainingand Education, LambungMangkuratUniversity, Banjarmasin
[5]Departement of Oral Radiology, Dentistry Faculty, Lambung Mangkurat University, Banjarmasin, Indonesia
[6]Departement of Cardiology, Ulin Hospital, Banjarmasin, Indonesia
[7]Public Health Center, Tabalong, South Kalimantan, Indonesia
E-mail: huldani@gmail.com

Article History: *Submitted: 20.01.2020* *Revised: 09.03.2020* *Accepted: 03.04.2020*

ABSTRACT

Background: VO_2 max is the maximum volume of oxygen that is processed by the body during intensive activities and is an indicator of the basic concepts of physical fitness. VO_2 max has milliliters per minute per kilogram of body weight. Factors that determine VO_2 max include heart lung function, age, aerobic muscle metabolism, body fitness, state of exercise, genetics, gender, multivitamin.

Purpose: To determine the difference in VO_2 max between prospective pilgrims based on age (adult and elderly), gender, hemoglobin level, and the number of leukocytes.

Methods: The total sample consisted of 60, each of 30 for gender and age variables. Sampling uses a purposive sampling method with inclusion criteria, namely age 36-55 years, has a normal BMI (18.5-24.9 kg / m2), physically fit, cooperative, does not consume stamina enhancing multivitamins, mild physical activity to moderate. VO_2 Max is measured by the Rockport method.

Result: Obtained the number of samples with VO_2 max fit in the adult group of 20 people (66.7%) and VO_2 max not fit 10 people (33.3%). In the elderly group sample with VO_2 max fit 11 people (36.7%) and less fit 19 people (63.3%). In the male group there were 20 people (66.7%) with VO_2 max fit and 10 people (33.3%) less fit. Whereas in the group of women found 11 people (36.7%) fit and 19 people (63.3%) less fit. The differences in each variable were analyzed using the Chi Square test. $\alpha = 0.02$ was obtained so that it can be concluded that there were significant differences in VO_2 max in the age and gender variables. The average hemoglobin level in the fit group was 14. g / dl. and the unfit group was 13.0 g / dl. Data were analyzed by t-test unpaired test. the results obtained $\alpha = 0.000$, which means there are significant differences in blood hemoglobin levels in groups with VO_2 max fitter and less fit. The average number of leukocytes in the group with VO_2 max fit was 7.83 thousand / µl and 7.27 thousand/µl in the less group. Data were analyzed by unpaired t test obtained p value = 0.69, which means there is no significant difference in the number of leukocytes in the fit and less fit groups.

Conclusion: There is a significant difference in VO_2 max between prospective pilgrims who are adults and elderly, between men and women, blood hemoglobin levels in the group with VO_2 max fitter and less fit, and there is no significant difference in the number of leukocytes in the fitter and less fit groups.

Keywords: VO_2 max, Age, Gender, Hemoglobin Levels, and Number of Leukocytes for Hajj Prospective Pilgrims

Correspondence:
Huldani
Department of physiology, Medical Faculty, Lambung Mangkurat University, Banjarmasin, Indonesia
E-mail: huldani@gmail.com
DOI: 10.31838/srp.2020.4.03

INTRODUCTION

Maximum aerobic capacity or maximal oxygen consumption (VO_2 max) is an indicator of the basic concepts of physical fitness. VO_2 max is the maximum amount of oxygen that can be delivered from the lungs to the muscles in milimeters, or in minutes per kilogram of body weight. Someone who has good stamina has a higher VO_2 max value, can do heavier exercises, and has higher concentration power compared to someone who is in poor stamina.[1]

Hajj requires good stamina, because the Hajj requires more physical activity compared to other worship. The series of pilgrimage is mostly done on foot, to the mosque, tawaf, sa'i, to places of pilgrimage, throwing pilgrimage, and other activities carried out on foot.[1,2]

Indonesian pilgrims are now able to perform the hajj on average after waiting for about 11-29 years. Based on data from the Ministry of Religion, until February 2017, South Sulawesi Province has the longest waiting period, which is 29 years. Then, followed by South Kalimantan with a waiting period of 28 years. That means if someone signs up for Hajj at the age of 17, and waits for 28 years, he will leave at the age of 45.[3,4]

Age 20-30 years is the peak age of heart and lung endurance and will then experience a decrease, this is due to increasing age so that a person will reduce various sports activities and tend to choose to work a lot, in addition there are also factors that decrease heart contraction heart muscle mass, total capacity.[5,6]

Based on the above explanation related to the length of the pilgrimage waiting list, then the possibility of pilgrims will leave at the age of 40 years and over. And according to data released by the Ministry of Religion of the Republic of Indonesia, for 2017, it was recorded that more than 50 percent were in the 41-70 year age group. -60 years old.

Male and female max VO_2 are different, this difference in VO_2 max is not apparent at a young age and is most evident during adulthood or middle age. Differences in VO_2 max for men and women are related to differences in composition and body size because the physiological bodies of men and women are different. In addition to body composition the difference in VO_2 max is also due to the

different hemoglobin concentrations of men and women. The composition of a woman's body is more fat than muscle compared to men which causes women to have a smaller VO2 max. The concentration of male hemoglobin is also higher than in women. The concentration of hemoglobin binds closely to the binding of oxygen needed by the body for the process of burning energy, so that men can optimally produce energy.[7]

MATERIALS AND METHODS

The method used in this research is analytic descriptive observational with cross sectional approach to determine differences in VO2Max based on age, sex, hemoglobin level, and the number of leukocytes in the prospective pilgrims in 2018 Hulu Sungai Tengah Regency, South Kalimantan. The sampling process was carried out using a purposive sampling technique according to the inclusion criteria. Minimum sample sizes of 30 samples per group in accordance with Gay & Diehl guidelines. Samples of elderly pilgrim candidates who meet the inclusion criteria are 64 prospective pilgrims, so a random sampling is done to get a total sample of 30 samples. The sample is a prospective Hajj pilgrims in Hulu Sungai Tengah district with inclusion criteria: 1) aged 26-65 years, 2) Has a Normal BMI, 3) Physically healthy and able to carry out research until completion, 4) Does not consume multivitamins, 5) Has a low level of activity - Medium, 6) Cooperative and willing to fill informed consent. The independent variables in this study were age, sex, hemoglobin level, and the number of leukocytes in the prospective pilgrims. The dependent variable in this study was VO2 max. VO2 Max is measured by the Rockport method with a simplified classification of being fit and less fit.

RESULTS AND DISCUSSION

Samples obtained in this study amounted to 60 people, namely 30 prospective female pilgrims and 30 prospective male pilgrims aged 26-65 years. The detailed characteristics of the samples obtained can be seen in Tables 1 and 2.

Table 1: Frequency Distribution of Sample Characteristics According to Age Group and Gender

Number	Variable	N	Respondent	%
1	**Gender**	60		
	Women		30	50
	Man		30	50
2	**Age**	60		
	26-45years		30	50
	46- 65 years		30	50

In this study the age of the sample was categorized into two groups, namely the young adult group aged 26-45 years and the elderly group 46-65 years. From the table data above, it can be seen the number of samples based on age characteristics obtained 30 people each (50%) in each group.

Table 2: Characteristic Frequency Distribution of Samples based on Hemoglobin Levels.

Variable	Mean	Std. Deviation	Minimum	Maximum
Level Hb(g/dl)	14.43	1.73	10.3	19.9

Each sample in this study was taken data on hemoglobin (Hb) levels and the number of leukocytes. Based on table 2 it can be seen that the average sample has a normal Hb, which is 14.4 g / dl, with the lowest Hb distribution in the sample that is 10.3 g / dl and the highest Hb is 19.9 g / dl. Graph 1 shows the distribution of hemoglobin in this study.

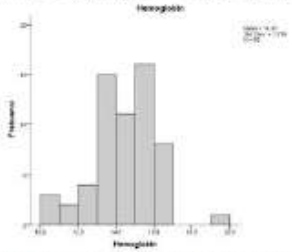


Fig. 1: Frequency distribution of hemoglobin in study samples.

The average number of leukocytes in the whole sample is 7,925 thousand / µl, which is also the normal value of the number of leukocytes. The highest number of leukocytes obtained in the sample was 12,900 thousand / µl, and the lowest number of leukocytes obtained in this study sample was 3,800 thousand / µl. Graph 2 shows the frequency distribution of leukocytes in this study sample.

Table 3: Characteristic Frequency Distribution of Samples based on Leukocyte Amounts.

Variable	Mean	Std. Deviation	Minimum	Maximum
Leukocyte count(thousand/ µl)	7.925	1.91	3.800	12.900

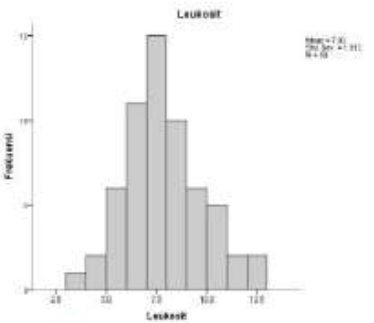


Fig. 2: Leukocyte frequency distribution of study samples.

To assess whether there is a significant difference in the distribution of VO2 Max fit and not fit in the adult and elderly age groups, a Chi Square test was performed. The significance value of the Chi Square test on this variable is 0.02. Then it can be concluded that there is a significant difference between VO2 max prospective pilgrims in the adult and elderly groups. This is in accordance with the researcher's hypothesis.

Table 4: Distribution of VO2 Max fit and unfit for Prospective Pilgrims for Adults and Seniors.

Age	Total	VO2max		p-value
		Fit	Less fit	
26-45	30 people	20people (66,7%)	10people (33,3%)	0,02
46-65	30 people	11 people(36,7%)	19 people(63,3%)	

The results of this study are supported by the research of Firman on Ngarojak district soccer athlete who stated that VO2 max has a strong relationship with age. The Word study uses the Spearman test with a relationship strength of 0.732. The results of the analysis also mentioned that the physical fitness risk of athletes aged 18-35 years had a 42 times fitter risk compared to athletes aged over 45 years.[8]

In addition, differences in VO2 max measurement results can be caused by many physiological factors. Because the heart lungs are different between adults and elderly people. Candidates for elderly pilgrims aged over 46 years have decreased VO2 max. This decrease occurs because the lungs, heart, and blood vessels begin to decline in function. The Word says that the age of 20-30 years is the peak age of the endurance of the heart and lungs and then will experience a decrease, this is due to increasing age so that a person will reduce various sports activities and tend to choose to work a lot, After a peak age of VO2 max then VO2 max will decrease with age.[9,10]

Dewi in her research also mentioned that the average decrease of VO2 max per year was 0.46 ml / kg / min for men, and 0.54 ml / kg / min for women. Thus, at the age of 55 years VO2 max is approximately 27% lower than the age of 25 years. In addition there are also factors that decrease heart contraction, heart muscle mass.[8,10]

Barrio's research states that effective physical exercise that is endurance can increase the value of VO2 max. However, in prospective elderly pilgrims, physical exercise routines and activities have decreased, so that VO2 max resistance also decreases. The state of exercise in the elderly has actually

been formed as an adult, so if the state of exercise during adulthood is already high then it is likely to have an impact on aging. In addition, fatigue is also one of the causes of decreased physical endurance in carrying out activities that will affect VO2 max. The older a person is, the energy requirements also decrease, and there is a decrease in muscle strength which causes faster fatigue.[16,17]

The distribution of VO2 max fitter and unfit for prospective male and female pilgrims can be seen in the table below.

Table 5: Distribution of VO2 Max fit and unfit for male and female prospective pilgrims.

Gender	Total	VO2maks		p-value
		Fit	Less Fit	
Man	30 people	20people (66,7%)	10people (33,3%)	0,02
Women	30 people	11 people (36,7%)	19 people (63,3%)	

The results of VO2 max measurement in 30 male samples found 20 samples categorized as fit and 10 samples categorized as unfit. In the group of women, 11 samples were fit and 19 samples were less fit. The difference in distribution above was assessed as significant using the Chi Square test, obtained p = 0, 02, it can be concluded that there is a significant difference between VO2 max male and female in prospective pilgrims. This supports the hypothesis that there are significant differences between male and female max VO2 in pilgrim candidates.

The results of this study differ from previous studies studied by Augustian et al. With the subject of research of students in grade V elementary school students said that men and women did not have a significant difference in VO2 max, where in the study the value of p = 0.724 was obtained. In Huldani's research, the subjects of the Darul Hijrah Islamic Boarding School students also found no significant difference between VO2 max for men and women, where in the study the value of p = 0.321 was obtained. Whereas in this study found significant differences in VO2 max values between men and women in prospective pilgrims who were on average mature or middle-aged, VO2 max values were influenced by various factors including gender, maximal VO2 values for men and women most clearly there is a difference in adulthood or middle age.[12,13]

Differences in VO2 max for men and women are related to differences in body size and body composition because the physiological bodies of men and women are different. The composition of a woman's body is more fat than muscle compared to men which causes women to have a smaller VO2 max. Besides these differences are also caused by differences in maximum muscle strength where in general male muscle strength is greater than women. In terms of body composition of women in general, more layers of fat compared to men. The difference in VO2 max between men and women apart from body composition is partly due to the different hemoglobin levels of men and women. This difference in VO2 max values between men and women is related to higher hemoglobin levels and also lower body fat in men than women. Higher hemoglobin levels in men than women cause differences in blood transport capacity which causes men to get far more oxygen during the exercise process so that their aerobic capacity is better. Hemoglobin levels in adult men normally range from 13.5 to 18.0 gr%, and in woman ranging between 11.5-16.5 gr%, differences in blood volume and hemoglobin levels between men and women are only slightly at a young age and there is a significant difference after puberty, because of the lower oxygen transport and a higher percentage of body fat, women tend to exhibit lower VO2 max values than men.[14,15]

Table 6: Mean ± standarddeviation (SD) and 95% confidence intervals for hemoglobin levels in the VO2 group are fitter and fitter.

Variable	VO2 Max				p-value
	Fit		Less Fit		
	Mean±SD	95% Confidence intervals	Mean	95% Confidence intervals	
Hemoglobin (g/dl)	14,9 ± 1,67	14,5-15,6	13,8 ± 1,62	13,2-14,4	0, 008

Saphiro-Wilk data normality test was performed on the Hemoglobin and Leukocyte variables, each p value> 0.05, which means the data on both variables were normally distributed. The average hemoglobin level in the fit group was 14, g / dl, and the unfit group was 13.8 g / dl. The mean of the two groups was assessed for differences with the unpaired t-test, the results obtained p = 0, 008, which means there was a significant difference in blood hemoglobin levels in groups with VO2 max fitter and less fit.

These results are in line with Siraga's research on the relationship of hemoglobin levels with VO2 max levels of PPLM athletes in North Sumatra province in 2017. To assess the significance and correlation of differences in Hb levels in both groups the Pearson test was obtained, the p value was 0.005 and the correlation value between variables was 0.687, which shows that the higher the hemoglobin level (within normal limits) the higher the VO2 max level of PPLM athletes in North Sumatra Province.18 The research conducted by Wahyudin on the Makassar SSB soccer player in 2016 also has similar results, namely there is a significant relationship between hemoglobin levels with VO2 max.[19]

Hemoglobin (Hb) contained in red blood cells functions as a carrier of oxygen, explaining that the number of red blood cells and the amount of hemoglobin (Hb) in the blood is very important in determining the body's ability to produce energy in physical and working activities.20 The better the

hemoglobin level, the more oxygen that can be transported, so that the body will be more optimal for producing energy. But if the hemoglobin level in the body is lacking, the performance of athletes when competing will be less than optimal because the body cannot meet the oxygen requirements to produce the energy needed by the athlete.[9,10]

Table 7: Mean ± standarddeviation (SD) and 95% confidence intervals for leukocyte counts in the VO2 group are max fitter and fitter.

Variable	VO2 Max				p-value
	Fit		Less Fit		
	Mean±SD	95% Confidence intervals	Mean	95% Confidence intervals	
Leukosit (thousand/ µl)	7,83±1,88	7,14-8,52	8, 02±1,97	7,27-8,77	0,69

The average number of leukocytes in the group with VO2 max fit was 7.83 thousand / µl and 7.27 thousand / µl in the less fit group. Both of them were tested by unpaired t test, obtained p value = 0.69, which means there was no significant difference in the number of leukocytes in the fit and less fit groups, because the p value> 0.05. The results of this study are in tune with Tenorio's research in 2014 concerning the relationship of leukocyte counts, nutritional status, and fitness status in adolescents, which actually shows a negative correlation between leukocyte counts and adolescent fitness status. [9]

The human body has a complex defense system called the immune system. This system allows the body to be able to react quickly and specifically to injury, inflammation, or infection. One of the most important components is leukocytes. Therefore it can be said that leukocytes are an indicator of the body's inflamation status. Leukocyte count is influenced by many things such as infection, inflammation, stress, and physical injury experienced by a person, both in acute and chronic conditions.24 VO2 max is not only used to assess fitness status, but is also a good parameter for assessing the cardiopulmonary system and risk atherosclerosis. Michishita et al. In their study of obese women, showed a negative correlation between VO2 max and monocytes. The better the fitness status, the lower the number of monocytes. From these results, it is believed that good fitness status can reduce a person's inflammatory status, so that it will have good implications for cardiovascular events.[10,26,27]

CONCLUSSION

From the results of the study it can be concluded that there are significant differences in VO2 max in the group of women and men, adults and elderly candidates for the 2018 Hajj Hajj Regency in Central Kalimantan, South Kalimantan. In addition, also found significant differences in hemoglobin levels in the VO2 max fit and less fit group. However, no significant difference was found in the number of leukocytes in the VO2 max fit and less fit group.

REFERENCES

1. Madina DS. (2007). Parulan's vital capacity value is related to the physical characteristics of various athletes in various sports. Bandung: Unpad.
2. Guyton and Hall. (2008). Medical physiology textbook. 11. Jakarta edition: EGC.
3. Ministry of Religion of the Republic of Indonesia. (2017). Hajj waiting list. [Jakarta; [internet]. [cited 2017 November] Available from: https://haji.kemenag.go.id/> node.
4. The Indonesian Ministry of Health. (2008). The composition of the body of the elderly. [internet]. [cited 2017 November] Available from: http://gizi.depkes.go.id/wp-content/ uploads / 2010/07 / composition-body-elderly.pdf.
5. Cengiz, Akalan, Robert, A. Robergs, Len, Kravitz. (2008). Prediction of VO2 max from an individualized submaximal cycle ergometer protocol. JEP online. 11(3).
6. Hodges ANH, Sheel AW, Mayo Jr., McKenzies, DC. (2007). Human lung density is not altered following normoxic and hypoxic moderate-intensity exercise: implications for transient edema. A physiol appl. 103: 111-8.
7. Mcardle WD, Katch, FI, Katch VL. (2006). Essentials of exercise physiology. Lippincott Williams & Wilkins.
8. Ilatnosari D. (2016). Relationship between the value of maximum oxygen volume and the value of breath length in choir members of Hasanuddin University students. [Scientific Papers] Makassar: Hasanuddin University.
9. Woo JS, Derleth C, Stratton JR, Levy WC. (2006). The influence of age, gender, and training on exercise efficiency. J Am CollCardiol. 47: 1049-57.
10. Word of FB. (2016). Factors related to physical fitness (VO2 max) soccer athletes. Surabaya: Unair.
11. Ilavalts of SR. (2017). The effect of jogging on increasing VO2 max in middle age in Surakarta. [Scientific Papers] Surakarta: Muhammadiyah University of Surakarta.
12. Noor KA, Huldani, Bewero A. (2013). Maximum Vo2 Comparison of Students and Students in Class V Elementary School: In Tabanio Village, Takisung District, Tanah Laut Regency, South Kalimantan. Periodical Medical Unlam. 9.1: 101-107.
13. Huldani. (2010). The influence of hemoglobin and sex levels on the maximum oxygen consumption of students from the Islamic Boarding School

DarulHijrah. Mirror of the World of Medicine. 180; 509-11.
14. Ferriyanto. (2010). Maximum Oxygen Volume. Bandung: Studio Press.
15. Hoeger, W.W.K, Hazlroeger, S.A. (2010). Principles and labs for physical fitness (7th ed). USA: Wadsworth.
16. Agung, SeptianNova. (2015). Survey of Physical Fitness Level on Lumajang Indonesian Football Association Players. Sports Coaching Education Study Program. UNESA Semarang.
17. Yunus, F. (2011). Maximum oxygen intake and pulmonary physiology of healthy male divers and non-divers. Indonesian Journal of Respirology. 31 (2): 61-71.
18. Siregar, FA. (2017). The relationship between hemoglobin levels and vo2max levels of PPLM athletes in North Sumatra province. Campus generation 6.2.
19. Wahyudin, Wahyudin. (2016) Relationship of Endurance (Vo2max) with Hemoglobin (Hb) Levels in SSB Hasanuddin Makassar Football Players. ILARA Journal, VII (1). pp. 86-91. ISSN 2086-4124.
20. Haas J, Brownlie T IV. (2001). Iron deficiency anemia and reduced work capacity: a critical review of the research to a causal relationship. J Nutr. 131: 676S-90S.
21. Ramayanthi C, et al. (2016). Profile of maximal oxygen volume (vo2 max) and hemoglobin (hb) levels in the Yongmoodo athletes of the Magelang Military Academy. Jorpres (Journal of Sports Achievement). 12.2.
22. Barik, R., Patnaik, A.N., Gulati, A.S. Fatal thrombocytopenia: A rare case with possible explanation (2012) Journal of Cardiovascular Disease Research, 3 (2), pp. 147-149. DOI: 10.4103/0975-3583.95372
23. Rahayu EP, Jaelani M. (2015). Fe intake, hemoglobin levels, and vo2 max in soccer school students. Journal of Nutrition Research. 3.1: 13-18.
24. Tenório TR, et al. (2014). Relation between leukocyte count, adiposity, and cardiorespiratory fitness in pubertal adolescents. Einstein (Sao Paulo). 12.4: 420-424.
25. Roitt IM, Delves PJ. (2011). Roitt's essential immunology. 12th Edition. Australia: Blackwell Publishing.
26. Michishita R, Shono N, Inoue T, Tsuruta T, Node K. (2008). Associations of monocytes, neutrophil count, and C-reactive protein with maximal oxygen uptake in overweight women. J Cardiol. 52 (3): 247-53.
27. Achmad H. Horax S, Ramadhany S, et.al. (2019). Resistivity of Ant Nest (*Myrmecodia pendans*) On Ethanol Fraction Burkitt's Lymphoma Cancer Cells (Invitro) Through Interleukin 8 Angiogenesis Obstacles (Il-8). Journal of International Dental and Medical Research „ISSN 1309-100X. Vol 12 No. (2) pp.516-523.
28. Achmad H, Sherly Horax, Sri Ramadhany, Irene Edith Rieuwpassa, Melyanti Sari, Hendrastuti Handayani, Marhamah F. Siregar, Sumintarti Sugiharto. (2019). Anti-Cancer and Anti-Proliferation Activity of Ethyl Acetate Extract From Ant Nest (Myrmecodia pendans) in Burkitt's Lymphoma Cancer Cells. Pesquisa Brasileira em Odontopediatria e Clinica Integrada. ISSN 1519-0501, 19 (1): e4325.

European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 08, Issue 01, 2021

VO2 MAX VALUE OF ADOLESCENT BASKETBALL PLAYERS AND THE DIFFERENCE IN THE LYMPHOCYTES AND EOSINOPHIL COUNT BETWEEN BASKET TRAINED AND NOT

Huldani[1], Ahmad Husairi[2], Azmawati[1], Dwi Setyohadi[3], Afiif Eko Wibowo[4], Gandhi Mahesa Priambodo[4], Aminuddin Prahatama Putra[5]

[1]Department of Physiology, Faculty of Medicine, Lambung Mangkurat University, Banjarmasin, South Kalimantan, Indonesia.
[2]Department of Anatomy, Faculty of Medicine, Lambung Mangkurat University, Banjarmasin, South Kalimantan, Indonesia.
[3]Department of Nutrition Science, Faculty of Medicine, Lambung Mangkurat University, Banjarmasin, South Kalimantan, Indonesia
[4]Student of Medical Education, Faculty of Medicine, Lambung Mangkurat University, Banjarmasin, South Kalimantan, Indonesia.
[5]Biology Education Department, Faculty of Teacher Training and Education, Lambung Mangkurat University, Banjarmasin, Indonesia

Email: huldani@gmail.com

Abstract:
This study aims to explain the VO2 max value in adolescents and the differences in lymphocytes and eosinophil levels after moderate aerobic exercise. The study was conducted with a post-test only control group design on 15 basketball player students and 15 non-basketball player students at SMAN 1 Banjarbaru. The sampling technique was carried out by using purposive sampling method. Measurement of VO2 max value was executed on the first day with MFT (Multistage Fitness Tes / Bleep Test) and measurement of lymphocytes and eosinophil levels was executed on the third day by trained medical personnel after the subject did the moderate aerobic exercise. Data analysis used was the Mann-Whitney test for VO2 max value and Saphiro-Wilk test for lymphocytes and the Mann-Whitney test for eosinophil levels. The results of the data analysis is the VO2 max value between groups were significantly different (p = 0.000) and there were no difference in lymphocytes (p > 0.05) and eosinophil (p > 0.05) count between groups after the moderate aerobic exercise. We conclude that basketball players student have a better VO2 max value than non-basketball players and moderate aerobic exercise were unable to make any significant difference between the groups in the number of lymphocytes and eosinophils.

Keywords: VO2 max, Lymphocytes, , Eosinophil, Basketball, Adolescents.

1. BACKGROUND

The transition period occurs in the late adolescent. Usually, the properties and habits carried out at this time will carry over into adulthood.[1,2] It is no exception to have a healthy lifestyle or not. It can also be influenced by several factors, namely spouse, occupation, friends, and others.[3] In adults who do not routinely do physical activity it is known that it is carried away from adolescence.[4]

Epidemiological studies show inactive lifestyles in adolescents have a link to increased mortality and morbidity of chronic diseases in later life.[5] Obesity is one of the diseases in adults related to the habit of not doing routine activities in adolescence.[6] Other diseases related to physical inactivity are coronary heart disease, osteoporosis, and cancer.[5]

Various studies that have been done show that a person who does routine activities in adolescence has many benefits. The short-term benefit is to improve the body's capacity by streamlining the flow of oxygen and blood circulation, while the long term is to avoid various diseases.[1,7]

There are many sports that teenagers love in Indonesia. One of the popular is basketball.[8] Basketball requires someone who plays it to move actively from all sides. The use of all limbs, good breathing arrangement, as well as

the consumption of a lot of energy makes basketball very good for the metabolism of the body when done to the maximum.[9,10] Physical exercise or exercising regularly can be beneficial for body fitness. The improvement of body fitness is meant by increasing VO_2 max and inducing changes in the adaptive and innate immune system physiologically.[11,12] Previous research has shown that VO_2 max in trained people is higher than untrained.[12] Then, this change in the immune system can be seen from changes in white blood cells mediated by HMGB1 or HPA cortisol.[13,14]

Apart from increasing VO2 max, aerobic exercises can increase the amount of eosinophil.[15] Eosinophils represent up to 6% of the bone marrow nucleation cells that remain and are routinely measured as a part of the complete blood cells count. Eosinophil plays a role in the immune system such as parasitic[16] disease. Under conditions of homeostatic, eosinophil in the peripheral blood is obtained in low numbers (<450-500 eosinophil /mL).[17]

Meanwhile, the adaptive immune system, lymphocytes, only increases during training and slowly decreases until after the completion of the exercise.[18] There were differences in results in several studies on white blood cells after physical exercise. Therefore, further research is needed to examine the theory and show new results in physical fitness after physical exercise between trained and untrained people.

2. RESEARCH METHODS

This research is cross sectional. The population in this study was all students of State High School 1 (SMAN 1) Banjarbaru. The samples in this study were divided into two, namely samples taken from 15 basketball players and 15 non-basketball players at State High School I (SMAN I) in Banjarbaru. The sample is cooperative and has filled out a consent sheet to be the subject of research. Picking up samples are done by using a purposive sampling technique according to inclusion criteria namely (a) Wants to be subject of research, (b) Male, (c) 15-18 Years Old (d) Healthy Physical (at the time of research is not sick, infection,and does not have history of serious diseases) (e) Cooperative (cooperate to conduct research procedures) (f) Body mass index (BMI) normal (20-25), (g) adolescent who doesn't smoke, (h) Not taking drugs that affect the amount of Lymphocyte and Eusinophyl at least 2 days before the research begin. The sample of adolescent basketball players is a SMAN 1 student who joins a basketball club and regularly conducts basketball practice at least three times a week for one hour per training session for a year. The sample of adolescents not basketball players is students who do not do regular sports. Students feeling signs of fatigue are welcome to stop and not continue training.

The research was conducted for 3 days. On the first day VO_2 Max measurement with MFT (Multistage fitness test). On the second day the research break. On the third day of research, will be done aerobic exercise medium intensity 12 minutes. The study subjects will be calculated their maximum pulse using tanaka formula. Once they have known their MHR, it is calculated 70-79% of their MHR and maintained for 12 minutes with a uniform rhythm. After a 12-minute run, the study subjects would have taken 3 cc of blood in the brachialis vein to measure lymphocyte and eusinophyl levels. The sampling and analysis of blood samples in the subject was carried out by trained personnel from the prodia laboratory. Trained health workers always accompany training sessions to prevent life-threatening occurrences.

3. RESULTS AND DISCUSSIONS

VO2 Max

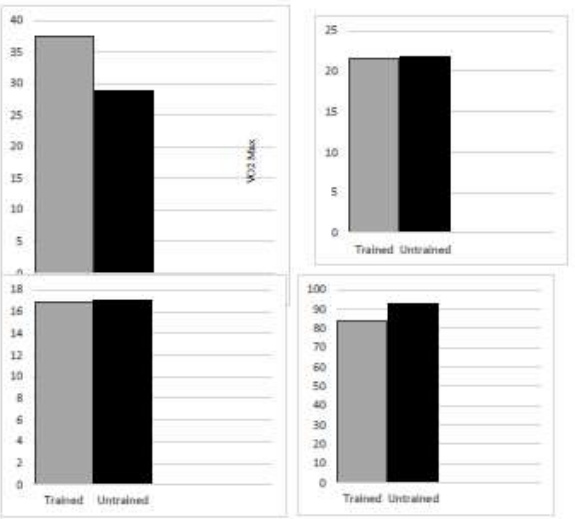
Table 1. Characteristics research subjects

No	Characteristics (Average elementary ±)	Basketball Group (Trained=15)	Non Basketball Group (Untrained n=15)
1	Age (Years)	16.93±0.258	17.067±0.703
2	BMI (kg/m^2)	21.65±2.10	21.68±5.91
3	Heart Rate	84.2±11.38	92.93±12.98
4	SO_2	97.26±2.57	96.93±3.73
5	VO_2 Max	37.48±3.98	28.85±2.62

Sample characteristics based on age, body mass index, VO_2 max are loaded on table 1. The average sample is 17 years old and body mass index, VO_2 max basketball players are higher than non-basketball players.

VO_2 max data was tested using mann-whitney test and found significant results ($p = 0.000$). This result is in line with the research of Anggi et al explained that there is a difference in VO2 max scores in male studentsaged 16-17 years after doing physical exercise for 6 weeks with before physical exercise. Stamina, Pola rest, and recovery period of each individual player is an aspect that influences the conclusions obtained. Based on these things, an important aspect is the optimal physical condition of the player. The player's physical condition affects the activity in training and following the training until the end, thus affecting the increase in endurance. [19]

In the study of Huldani et al[20], there was a significant difference in the VO2 max value between men who were fit (64.3%) and not fit (37.5%). Rahman[21] in his research also explained that there are differences in SB-Runners members who regularly do exercises (1-2 times a week) and do not practice regularly (<1-2 times a week). There is a significant difference ($p<0.001$). This conclusion is also supported by Hatle's research. Hatle examined 21 students with an average of 23-year-old subjects, had a normal BMI, did not smoke, and were physically healthy. The study subjects were divided into 2 treatment groups namely groups with moderate intensity exercise and high intensity exercise. Then the sample was treated with aerobic training 24 sessions conducted for 8 weeks. The group given moderate intensity training increased VO2 max during the training period until the training period ended with VO2 max increasing 10.7% progressively and significant value $p= 0.001$.



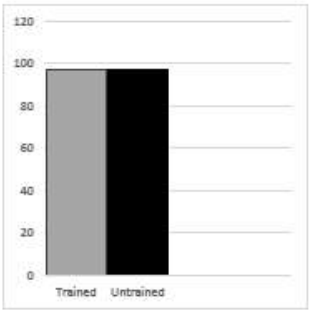


Figure 1.
Bar Chart Average VO2 Max, BMI, Heart Rate, SO2, Ages in Trained Adolescents and Untrained Adolescents

Table 2.
Results of analysis of the number lymphocytes and eosinophil research subjects

	Variable	Average	SD	P
Lymphocyte	Trained Adolescents	42.0267	8.00	>0.05
	Untrained Adolescents	41.0067	8.10	
Eosinophil	Trained Adolescents	2,20	2.75	>0.05
	Untrained Adolescents	1,60	1.44	

Lymphocytes

On the third day of research, aerobic exercise was running for 12 minutes and blood collection after doing the exercise. To find out the normality of the distribution of data on the blood lymphocyte levels of adolescent basketball players and not basketball players of each group conducted saphiro-wilk test, obtained normal distributed data for both groups of probandus research. In the amount of blood lymphocytes of these two groups there was no significant difference in blood lymphocyte levels after 12 minutes of moderate aerobic physical exercise. Kasab's study explained that there was an increase in the number of lymphocytes 30 minutes after moderate intensity physical exercise from a group of trained and untrained samples compared to before physical exercise. But the differences between the two groups are meaningless. It can be affected by gender, congenital diseases, and individual fitness. Rooney *et al.*[23] in favor that lymphocytotis occurs at 30-60 minutes after acute exercise.

Lymphocytes and monocytes will come out quickly and are affected again by intravenous catheter blood retrieval time. Lymphocyte levels depend on hemodynamic factors after cessation of physical exercise, most likely this is also influenced by individual fitness levels.[22]

Stress is a psychological/ physiological tension caused by stimuli. The mechanism of occurrence of stress begins with the increasing Corticotropine Releasing Hormone (CRH). CRH which has a role as a cortisol regulator in the blood will be secreted into the pituitary portal. Then Corticotropine Releasing Hormones will secrete Adenocortical Stimulating Hormone (ACTH).[21]

ACTH triggers the adrenal cortex to secrete the hormone cortisol. High cortisol levels can suppress inflammatory cells. Lymphocyte and macrophag are important cells in immunity and the process of inflamation. Because lymphocytes have a role in the adaptive immune system while macrophags have a role in the innate immune system.[13]

Short-term exercise and Long-term exercise proved to be the stressor of the athlete's redox status change for acute and chronic response in homeostasis. Biomarkers in acute exercise have more effect on redox homeostasis than long-term exercises. Inflammatory mediators such as IL-6 and IL-1ra are the most sensitive cytokine markers in physical exercise for adolescent athletes.[23] This may have an effect in the end with the results of the study so that it is obtained is meaningless.

Harun mentioned in his study there is a difference in IL-6 levels and lymphocytes after mild and moderate aerobic exercise in adolescents. In this study has different results, perhaps because it differs on the division of research subject groups and the form of exercise given. In the study of Harun, the subject of research was divided into 3 groups (plus control variables) and the exercises performed included chronic because it was done for 12 weeks.[24]

Research giacco *et al.*[25] explained that there was no significant change in lymphocytes in professional football athletes after practice. These results may be influenced by male-only gender, narrow age range, and lack of control population. One of the interesting things is that it turns out that aerobic physical exercise decreases the production of IL-4. 12 minutes of aerobic physical exercise can be useful in improving the symptoms of allergy and asthma sufferers if they often do regular physical exercise. So aerobic physical exercise is regularly considered to be a therapy for asthmatics.

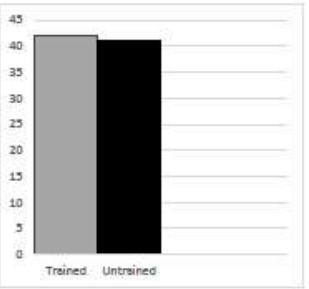


Figure 2.
Bar Chart of Average Lymphocyte Count in Trained Adolescents and Untrained Adolescents

Eosinophil

In research regarding the number of eosinophils. The results of the Mann-Whitney test obtained a P value> 0.05 (table 2).

The possibility of this happened because the training given by the researcher did not cause skeletal muscle injury to basketball players and not basketball players according to Setyohadi research. The results were not statistically significant and the difference in the number of eosinophils after treatment was carried out in the three groups, namely the light aerobic exercise group, moderate aerobic exercise group and control group ($p > 0.05$) .[26] It is also supported in the Harahap NS study. There was a significant difference between swimming exercise as hard as possible in mice ($p = 0.000$), because it was in accordance with the training that was able to provide muscle lesions.[27] In the study of Sodique et al., Significant results were obtained by doing strenuous physical exercise on subjects of average age. 22 years ($p < 0.01$) and eosipenia occurs due to excessive physical activity.[28] Yuliarto H's research found insignificant results in moderate intensity aerobic exercise ($p > 0.05$) .[29]

The cause of meaningless results of the eosinophil count probably comes from physical exercises performed by basketball players and non-basketball players who experience an increase in cortisol, which suppresses the inflammatory process resulting in hindering the number of eosinophil. Exercises can be considered as a trigger for muscle injury which activates the hypothalamic-pituitary-adrenal axis. There will be an increase in number of cortisol as young basketball players and non-basketball players are given training. Cortisol enhancement is a common response to muscle injury. Therefore, light-intensity exercises will not cause muscle injury which results to no change in cortisol. Exercises that can be a cause to muscle injury increase cortisol enhancement. Cortisol circulates in the plasma. It mobilizes substances needed for cells metabolism. Cortisol also affects protein metabolism. Cortisol has a metabolic effect which increases the rate of synthesis of RNA protein in some parts of the body and increases the rate of lipogenesis in other parts such as the face and body. The effect of lipids on tissue is quite specific because not all parts show an increase in lipid deposition or lipolysis. Cortisol works as an immunosuppressant by suppressing protein synthesis including immunoglobulin synthesis. Cortisol also reduces the population of eosinophil, lymphocytes, and macrophages in the peripheral blood. Glucocorticoids decrease the number of eosinophil in blood by increasing their sequestration in the lymph and lungs. The typical effect of cortisol distribution on white blood cells reduces the number of eosinophil from normally 270 cells/aL to 20 cells/aL. Therefore, there is a cortisol enhancement in acute exercises on moderate intensity exercises resulting in suppression in the number of eosinophil in blood or eosinopenia. Though it seems contradictory because other opinion claims that the occurrence of eosinopenia is relatively related to the presence of signs of lymphocytosis or the suppression of the inflammatory process so as to hinder the increase in the number of eosinophil in the blood.[29,30,31]
Therefore, in this study, there is an anti-inflammatory effect resulting from cortisol which causes suppression in the number of eosinophil, so that there is no significant difference between basketball players and non-basketball players.

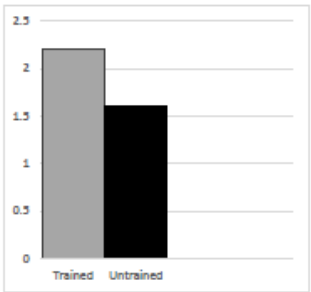


Figure 3.
Bar Chart of Average Eosinophil Count in Trained Adolescents and Untrained Adolescents

4. CONCLUSION

The results of this study concluded that the fitness level (VO_2 Maks) of adolescent basketball players is better than that of non-basketball players. In addition, there was also asignificant difference in the number of lymphocytes and eosinophils levels between adolescent basketball players and non-basketball players after a 12-minute moderate-intensity aerobic exercise.

Based on the weaknesses of this study, researchers suggest that researchers may further explain between adolescent and adult body responses to inflammation during physical exercise or during exercise, exercise duration, type of exercise, exercise intensity, and what frequency can cause optimum differences in lymphocytes and eosinophils levels of basketball players and not basketball players after aerobic physical exercise. Further researchers can also continue similar research models in order to look for differences in cortisol hormone response.

5. REFRENCES

1. Mikaelsson K, Rutberg S, Lindqvist AK, Michaelson P. Physically inactive adolescents' experiences of engaging in physical activity. European Journal of Physiotherapy. 2019; 5:1-6.
2. Mize TD. Profiles in health: multiple roles and health lifestyles in early adulthood. Soc Sci Med. 2017;178:196–205.
3. Mize TD. Profiles in health: Multiple roles and health lifestyles in early adulthood. Social Science & Medicine. 2017 Apr 1;178:196-205.
4. Herman KM, Craig CL, Gauvin L, Katzmarzyk PT. Tracking of obesity and physical activity from childhood to adulthood: the Physical Activity Longitudinal Study. International Journal of Pediatric Obesity. 2009 Jan 1;4(4):281-8.
5. Gleeson M. Links between sedentary behavior, chronic inflammation and chronic diseases. In: Gleeson M, Bishop N, Walsh N, editors. Exercise immunology. New York; Routledge, 2013; p. 301-8.
6. Haslam DW, James WP. Obesity. Lancet. 2005;366:1197-209.
7. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U, Lancet Physical Activity Series Working Group. Global physical activity levels: surveillance progress, pitfalls, and prospects. The lancet. 2012 Jul 21;380(9838):247-57.
8. Rozi MF. Effect of Exercise Method and Nutritional Status of Ability VO2max on Basketball Players Performance. International Conference of Physical Education (ICPE 2019) 2020 Aug 6 (pp. 234-236). Atlantis Press.
9. Aschendorf PF, Zimmer C, Delextrat A, Engelmeyer E, Mester J. Effects of basketball-specific high-intensity interval training on aerobic performance and physical capacities in youth female basketball players. The Physician and sportsmedicine. 2019 Jan 2;47(1):65-70.
10. Oliver J. Seri Dasar-dasar Olahraga. Dasar-dasar Bola Basket. Cara yang lebih baik untuk mempelajarinya. Bandung: Pakar Raya. 2009.
11. Pedersen BK, Hoffman-Goetz L. Exercise and the immune system: regulation, integration, and adaptation. Physiological reviews. 2000;80(3):1055-81.
12. Sharma VK, Subramanian SK, Radhakrishnan K, Rajendran R, Ravindran BS, Arunachalam V. Comparison of structured and unstructured physical activity training on predicted VO2max and heart rate variability in adolescents--a randomized control trial. Journal of basic and clinical physiology and pharmacology. 2017 May 1;28(3):225-38.
13. Kantasa VD, Kusumawardani B. The effect of electrical shock stressor on lymphocytes and macrophages in gingival tissue of sprague dawley rats. Pustaka Kesehatan. 2016; 11;4(1):48-54.
14. Li G, Liang X, Lotze MT. HMGB1: the central cytokine for all lymphoid cells. Frontiers in immunology. 2013. 20;4:68.
15. Setyawan S. Eosinophilia in physical exercise stressor: pathobiology or physiobiology?. Folia Medica Indonesiana. 2005;41(4):261.
16. Wibowo C, Dese DC. Hubungan indeks masa tubuh dengan VO_2max pada Atlet bolabasket. Journal Physical Education, Health and Recreation. 2019;3(2):19-25.
17. Flores-Torres AS, Salinas-Carmona MC, Salinas E, Rosas-Taraco AG. Eosinophils and respiratory viruses. Viral immunology. 2019;32(5):198-207.
18. Prayuda AY, Firmansyah G. Pengaruh latihan lari 12 menit dan lari bolak balik terhadap peningkatan daya tahan VO2 max. Jurnal Pendidikan Jasmani, Olahraga dan Kesehatan. 2017;1(1):13-22.
19. Rahman AS, Asmawati A, Husairi A. Perbandingan Volume Oksigen Maksimal Anggota Komunitas South

Borneo Runners yang Jogging Rutin dengan Tidak Rutin. Homeostasis. 2020 Apr 28;3(1):37-42.

20. Huldani, Harun Achmad, Aryadi Arsyad, Aminuddin Prahatama Putra, Bayu Indra Sukmana, Dwi Laksono Adiputro, Julia Kasab. Differences in VO2 Max Based on Age, Gender, Hemoglobin Levels, and Leukocyte Counts in Hajj Prospective Pilgrims in Hulu Sungai Tengah Regency, South Kalimantan. SRP. 2020; 11(4): 09-14. doi:10.31838/srp.2020.4.03
21. Huldani , Siti Kaidah, Julia Kasab, Fauziah, Muhammad Hasan Ridhoni, Wafa Ahdiya. VO2 Max in River Beach communities in hst district by age, gender, and mobile immunity (neutrofil and limfosite). European Journal of Molecular & Clinical Medicine, 2020; 7(8): 1126-1132
22. Rooney BV, Bigley AB, LaVoy EC, Laughlin M, Pedlar C, Simpson RJ. Lymphocytes and monocytes egress peripheral blood within minutes after cessation of steady state exercise: A detailed temporal analysis of leukocyte extravasation. Physiology & behavior. 2018; 194:260-7.
23. Varamenti E, Tod D, Pullinger SA. Redox homeostasis and inflammation responses to training in adolescent athletes: A systematic review and meta-analysis. Sports medicine-open. 2020;6(1):1-7.
24. Harun L, Pascasarjana P, Muhammadiyah U, Aerobik L. Perbandingan kadar interleukin-6 dan jumlah limfosit setelah (Comparation Of The Levels Of Interleukin-6 And The Number Of Lymphocytes After Mild And Moderate Aerobic In Adolescents). 2018;1(2):64–8.
25. Del Giacco SR, Scorcu M, Argiolas F, Firinu D, Del Giacco GS. Exercise training, lymphocyte subsets and their cytokines production: experience of an Italian professional football team and their impact on allergy. BioMed research international. 2014; 2014.
26. Setyohadi D. Perbedaan kadar interleukin 4 dan jumlah eosinofil setelah latihan aerobik ringan dan sedang pada remaja. Berkala Kedokteran Unlam. 2016;12(1):103-16.
27. Harahap NS. Pengaruh aktifitas fisik maksimal terhadap jumlah leukosit dan hitung jenis leukosit pada mencit (Mus Musculus L) jantan. USU e-Repository ©. 2008;1–24.
28. Sodique NO, Enyikwola O, Ekanem AU. Exercise-induced leucocytosis in some healthy adult Nigerians. African Journal of Biomedical Research. 2000;3(2):85-8.
29. Yuliarto H. Pengaruh latihan aerobik intensitas rendah dan menengah terhadap konsentrasi eosinofil : Penelitian eksperimental laboratorik. [dissertation]. Universitas. 2001.
30. Sabag N, Castrillon MA, Tchernitchin A. Cortisol-induced migration of eosinophil leukocytes to lymphoid organs. Experientia. 1978 May 1;34(5):666-7.
31. Hötting K, Schickert N, Kaiser J, Röder B, Schmidt-Kassow M. The effects of acute physical exercise on memory, peripheral BDNF, and cortisol in young adults. Neural plasticity. 2017;2016.

European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 08, Issue 01, 2021

DIFFERENCES OF VO2 MAX VALUE IN ADOLESCENTS AND CORTISOL LEVELS, COUNT OF LEUKOCYTES, MONOCYTES, AND NEUTROPHYL AFTER 12 MINUTES OF MODERATE AEROBIC EXERCISE

Huldani[1], Ahmad Husairi[2], Abdullah Zuhair[3], Muhammad Rafagih[3], Zhasifa Khoirunnisa Suwanto[3], Wisnu Wiryawan[3], Muhammad Zaini[3]

[1]Department of Physiology, Faculty of Medicine, University of Lambung Mangkurat, Banjarmasin, South Kalimantan, Indonesia.
[2]Department of Anatomy, Faculty of Medicine, University of Lambung Mangkurat, Banjarmasin, South Kalimantan, Indonesia.
[3]Student of Medical Education, Faculty of Medicine, University of Lambung Mangkurat, Banjarmasin, South Kalimantan, Indonesia.

Email : huldani@gmail.com

ABSTRACT

This study aims to mention the difference in VO2 max value in adolescents and the difference in leukocyte, monocytes, and neutrophil levels after 12 minutes of moderate aerobic exercise. The study was conducted using a cross-sectional study in 15 basketball players & 15 non-basketball students at SMAN 1 Banjarbaru. The sampling technique was carried out using purposive sampling method. Measurement of VO2 max value was carried out on the first day using the MFT (Multistage Fitness Test / Bleep Test) and measurement of leukocyte levels was carried out on the third day using blood collection after the patient did 12 minutes of moderate aerobic exercise. Data analysis used the Mann-Whitney test for VO2 max values & unpaired t test for the number of leucocytes, monocytes, neutrophils & cortisol levels. The results of the data analysis showed that there were still significant differences in the VO2 max value in basketball & non-basketball players ($p > 0.05$), monocytes ($p > 0.05$), & neutrophils ($p > 0.05$) and there were significant differences in levels. cortisol ($p < 0.01$) after 12 minutes of moderate aerobic exercise in basketball and non-basketball students. The conclusion of this study is that 12 minutes of moderate aerobic exercise resulted in a higher increase in cortisol levels in basketball players compared to non-basketball players and the average value of leukocytes, monocytes, and neutrophils in basketball players was lower than non-basketball players. This is because the release of cortisol is a form of adaptation to the body's stress due to training, and becomes anti-inflammatory as a result reduces the number of leukocytes, monocytes and neutrophils of basketball players. 12 minutes of aerobic exercise can be used as a method to increase the body's immune system and explain the homeostasis process in adolescents in a good way.

1. INTRODUCTION

In 2019, the WHO stated that most of the global population tends to be passive in physical activities, thus putting their health at risk in the future, therefore advising them to exercise weekly, especially at moderate intensity, for 2 hours 30 minutes for people aged 18-64 years. Regular exercise is considered capable of increasing life expectancy and reduce the risk of the development of diseases.[1,2,3,4,5,6] Basketball sport is one among so many type of exercise which has gained a huge attention among the Indonesian.[7,8,9] Despite the prominent utilization of anaerobic metabolism in basketball game, aerobic metabolism is also used alternately with anaerobic metabolism.[10,11]

Aerobic exercise is a physical activity which utilizes aerobic metabolism as its energy source and uses continuos and regular contraction of large muscle groups over a period of time.[11,12,13,14] Intensity is a part in aerobic exercise.[11] Moderate intensity aerobic exercise is the most studied aerobic exercise and utilizes comparable amount of energy to brisk walking.[14]

Exercise can affect VO2 max therefore exercise is related to a person's fitness level.[15] To value the VO2 max , a 12 minute run is often used in the procedure.[16,17,18] In addition, exercise is also related to the immune system

and neuroendocrine system.[11] The connection between exercise and the immune system was first investigated by David Nieman who observed, in his research, a lack of reports of acute respiratory infection complaints in individuals who routinely do moderate intensity of physical exercise.[8,19]

The number of white blood cells in the blood can be affected by exercise. Exercise can cause a temporary increase of white blood cells count returning to normal within 6-24 hours. Neutrophil and lymphocyte activation plays a major role in this phenomenon, however, monocyte activation also plays a minor role.[20]

Exercise is capable of affecting the hipotalamic-pituitary axis response which causes the release of the corticotropin hormone (CRH) from the hypothalamus to the cells of the anterior pituitary, resulting in the release of adrenocorticotropic hormone (ACTH) into the bloodstream. ACTH in the blood then stimulates the release glucocorticoids (cortisol)from the adrenal cortex.[15]

2. METHOD

This study used a cross sectional method. The population is all students of Sekolah Menengah Atas Negeri 1 (SMAN 1) Banjarbaru. The sample was selected using criteria and divided into two, a sample of 15 basketball players and 15 non-basketball players. The sample selection criteria were done using purposive sampling method using inclusion criteria, such as men, aged 15-18 years, physically healthy at the time of the study, and had no history of heart disease, lung disease and allergies, research subjects cooperative in research, didn't smoke, not taking drugs that affect the number of leukocytes, monocytes, and neutrophils at least 2 days before the event, body mass index (BMI) in the normal value range (20-25). The sample of basketball players is students of SMAN 1 Banjarbaru who are members of the basketball club and have been playing basketball for at least one year, three times a week for one hour per training. The study will be stopped if the subject experiences signs of fatigue during exercise so that he is unable to complete the exercise. After being selected the subject is then asked to cooperate to fill out the consent form to become the research subject.

The study lasted 3 days. On the first day, VO_2 max measurements were done using the MFT (Multistage fitness test). The second day the subject was rested. On the third day, the research subjects had their maximum pulse rate calculated using the Tanaka formula, then the research subjects would use oxymetry and warm up in the form of running in groups consisting of 3 people per group until the 70-79% pulse rate target was achieved. After reaching the target, subjects were asked to keep running for 12 minutes with a rhythm as a form of 12 minutes of moderate intensity aerobic exercise. Then the blood was drawn to analyze the number of leukocytes, monocytes, neutrophils, and cortisol levels. The subject's blood was drawn as much as 5 cc in the brachial vein after 12 minutes of moderate intensity aerobic exercise. Blood sampling and analysis of the subjects were done by personnel from the Prodia laboratory. Health workers are prepared to prevent unwanted things.

3. RESULTS AND DISCUSSION

Sample characteristics were based on age, pulse rate, body mass index, body weight, systolic and diastolic blood pressure.

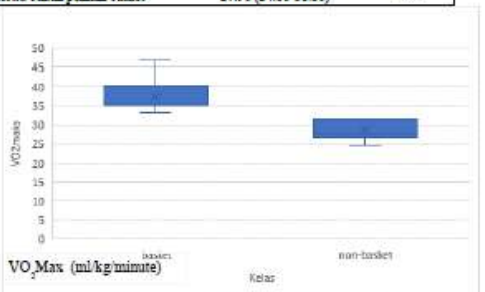
Table1. Characteristics of research subjects

Characteristics (Average ± SD)	Basketball group (basketball player Student n=15)	Kelompok Non Basket (basketball player Student n=15)
Age (years)	16.93±0.258	17.07±0.495
O_2 Saturation (%)	97.27±2.576	96.93± 3.731
Pulse per minute	84.20±11.384	92.93±12.981
Body mass index (kg/m^2)	21.65±2.104	21.68±5.911
Height (cm)	167.37±8.067	172.00±5.305
Body weight (kg)	61.13±10.034	64.33±18.289
Systolic blood pressure (mmHg)	127.53±14.282	132.20±13.078
Diastolic blood pressure (mmHg)	78.73±7,601	82.87±9.797

The characteristics of the research subject indicate the state of the research subject. Based on the data in table 1, we can conclude that the research subjects are in good health so that they are able to carry out the research procedures assigned to them.

Table 2. VO_2 max value

Variable	median (minimum-maximum)	p
Siswa pemain basket	35.75 (33.20-46.50)	<0.01
Siswa bukan pemain basket	27.90 (24.60-31.80)	

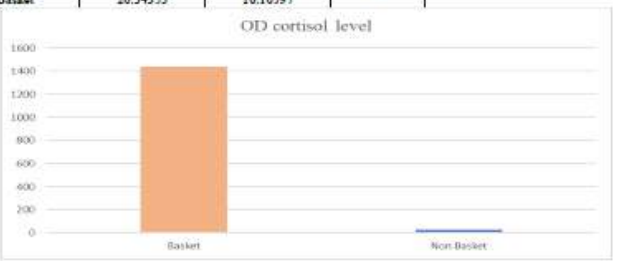


The VO2 max value of basketball trained adolescents was higher than that of untrained basketball youth. Research by Buchan DS et al. It was found that physical exercise three times a week for seven weeks with moderate intensity increased VO2 Max values compared to those who did not exercise in adolescents (p = 0.000). That this is probably due to the influence of moderate intensity physical exercise on cardiac output, where physical exercise results in an increase in cardiac output due to an increase in stroke volume.[31]

There are 2 factors, central and peripheral, increasing the VO2 max value based on a study by Macpherson REK et al. Centrally, an increase in stroke volume and a little increase in the maximal heart rate can increase the VO2 max value. Peripherally, an increase in the difference in arterial-venous oxygen, influenced by oxygen transport to active muscle fibers, local enzyme adaptation, and mitochondrial density, can increase the VO2 max value. A peripheral increase in VO2 max is observed in sprint interval training.[32]

Table 3. Blood cortisol OD value

Variable	OD value	SD	P
Basket	1440.054	1863.176	<0.01
Non Basket	26.34353	16.10597	



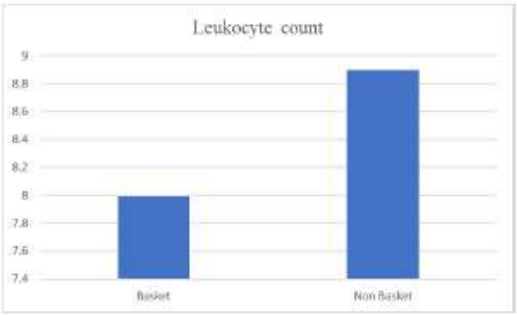
In the study, there was a statistically significant difference in cortisol levels after moderate intensity exercise among basketball players and non-basketball players ($p < 0.01$) (table 3). This shows that there is a significant difference in the cortisol value of basketball-trained adolescents compared to basketball-trained adolescents after 12 minutes of moderate aerobic running intervention. As in several previous studies that exercise and physical activity can be a source of stress for the body and have an impact on other body systems and have the potential to affect homeostasis.[23,24]

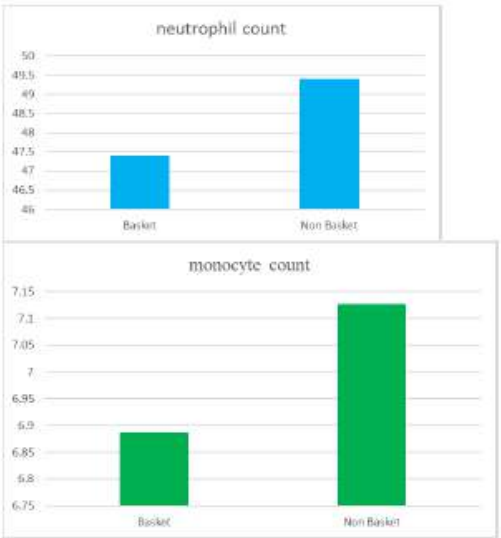
Exercise is capable of affecting the hipotalamic-pituitary axis response which causes the release of the corticotropin hormone (CRH) from the hypothalamus to the cells of the anterior pituitary, resulting in the release of adrenocorticotropic hormone (ACTH) into the bloodstream. ACTH in the blood then stimulates the release glucocorticoids (cortisol)from the adrenal cortex.[15]

In this research's results, the cortisol levels of basketball player group was higher than the non-basketball group. The results showed a similarity with a study by Minetto et al which observed a higher salivary cortisol levels in competitive athlets than sedentary individuals.[25] A possible reason is that the basketball player group HPA axis has a better response to stress than the non basketball player group which is important for the basketball player group to be able to adapt to chronic stressfull situation such as competition and daily exercise.[26]

Table 4. leukocyte, neutrophil, monocyte count

	Variable	mean	SD	P
leukocyte	Basket	7.9933	2.04152	0.35
	Non Basket	8.9	2.79438	
neutrophil	Basket	47.4	9.02623	0.564
	Non Basket	49.4	9.70493	
monocyte	Basket	6.8867	1.56245	0.454
	Non Basket	7.1267	3.51069	





The results of this study were that the difference in the leukocyte counts, neutrophil counts, and monocyte counts were insignificant between basketball player group and non basketball player group after 12 minutes of moderate intensity aerobic physical exercise ($p > 0.05$) (table 4). It is also possible that this result is due to the delayed increase in neutrophils which is influenced by the suppressive effect of cortisol on the increase in neutrophils in the subject.

A similarity was observed in the study of Zar Abdossaleh et al., who obtained a statistically insignificant difference in the number of leukocytes before and after 60 minutes of moderate intensity physical exercise in male judo athletes ($p > 0.05$).[25] In addition, Bartlett DB et al., also observed insignificant changes in the leukocyte count between before and after 30-45 minutes of moderate intensity of physical exercise, three times a week, for 10 weeks in adults ($p > 0.05$).[26]Those two researches shared a similar finding with our research in which there were a insignificant effect of moderate intensity exercise to white blood cell count. Albeit those two researches, there were also studies which had a conflicting results with ours. Khoshnam MS et al., Found that the mean white blood cell count of male athletes was significantly lower than that of non-athletic male after aerobic exercise.[29]

This conflicting result may be due to the use of the Bruce protocol by Khosnam et al., as their exercise procedure in their study in which participants ran on a treadmill at a speed and dryness which increased slowly every 3 minutes until they were exhausted and unable to continue exercising.[30,31] This protocol was clearly different from the training procedure we gave our study participants in which our samples weren't exerted to exhaustion. Therefore this difference is likely to cause a difference in exercise intensity between the Bruce protocol participants and our study participants.

Another reason for the statistically insignificant result of this research is the increasing cortisol levels after an acute physical exercise as mentioned in several studies.[32-35] The cortisol affects the increase in neutrophils as

reported in the study of VanBruggen et al.[32] an anti-inflammatory effect resulted from the suppression of pro-inflammatory cytokine expression by the increasing cortisol levels restrains the increase in the number of leukocytes.[36,37] This notion is supported by a results of a study which showed that giving a glucocorticoid dose that resembles cortisol levels under a stress is able to suppress IL-6 and this effect is more significant than giving excessive glucocorticoid doses or suppressing glucocorticoids.[38] This indicates that the increase in cortisol in response to a stress (physical exercise) can affect the immune system.

In addition, cortisol levels may also be related to the timing of the physical exercise. Glucocorticoid levels increase in the morning and decrease at night. The Increasing morning glucocorticoids levels give rise to an increasing expression of CXCR4 in CD8 + and CD4 + cells which cause a remobilization of CD8 + and CD4 + cells from blood to bone marrow ,in which a lot of CXCL 12 are expressed, which activates CXCR4 therefore decreasing the number of CD8 + and CD4 + cells.[39] This phenomenon possibly suppresses the increase in the number of leukocytes thus resulting in an insignificant different between the white blood cell count of basketball player group and non-basketball player group. This notion is supported by a research done by Albayrak C. D et al., in which they found that the cortisol levels of basketball players during pre-competition training was inversely proportional to their white blood cell counts ($p < 0.05$) and their CD4 + cell counts ($P < 0.01$).[40]

Another possibility that causes insignificant difference in the WBC count between samples of basketball players and non-basketball players after 12 minutes of moderate intensity aerobic exercise is the white blood cell (WBC) migration. the interaction between WBC and post-capillary venous endothelial cells around the site of inflammation is the main process in WBC migration. This interaction will cause the leukocytes to be trapped in the endothelial cells, then adhere to and migrate into the site of inflammation from the lumen of blood vessel.[41,42,43] This migration process was likely to cause accumulation of WBCs in the veins of the lower extremities due to the prominent utilization of lower extremity muscles in our 12 minutes of moderate intensity aerobic exercise. On the other hand, the blood sample used came from the cubital vein therefore causing a mismatch between the location of blood collection and the location of inflammation so that the blood drawn does not reflect the ongoing inflammatory process. This results in an insignificant difference between the white blood cell count of basketball players and non-basketball players.

4. CONCLUSION

Based on the results and discussions of this research, the researcher concluded that moderate intensity aerobic exercise for 12 minutes had insignificant effect on the differences in the leucocyte counts, neutrophils counts, and monocyte counts of basketball players and non-basketball players. the insignificant result is possibly caused by the migration process of WBC amd the lack of training duration and intensity which are important in the formation of muscle injury therefore resulting in a similar result from a measurment of resting blood samples, as described in the study of Baffour-Awuah B et al.[35] In addition, increasing cortisol levels resulted from stress induced exercised may also impact the finding of this research thus resulting in insignificant different between the leucocyte counts, neutrophils counts, and monocyte counts of basketball players and non-basketball players due to the cortisol anti inflammatory effect.

Furthermore, the research also found that the basketball player group had a better fitness level than the non-basketball player group and a statistically different cortisol level between both group with basktetball player group has higher cortisol levels than non basketball player group

REFERENCES

1. Bennie JA, De Cocker K, Teychenne MJ, et al. The epidemiology of aerobic physical activity and muscle-strengthening activity guideline adherence among 383,928 U.S. adults. Int J Behav Nutr Phys Act. 2019;16(1):1–11.
2. Sand KL, Flatebo T, Andersen MB, et al. Effects of exercise on leukocytosis and blood hemostasis in 800 healthy young females and males. World J Exp Med. 2013;3(1):11.
3. Singh R, Pattisapu A, Emery MS. US physical activity guidelines: current state, impact and future directions. Trends Cardiovasc Med. 2019.
4. Kokkinos P. Physical activity, health benefits, and mortality risk. ISRN Cardiol. 2012;2012:1–14.
5. McKinney J, Lithwick DJ, Morrison BN, et al. The health benefits of physical activity and cardiorespiratory fitness. B C Med J. 2016;58(3):131–7.
6. Mallo Ferrer F. Physical activity and exercise [Internet]. 2nd ed. Encyclopedia of Endocrine Diseases. Elsevier Inc.; 2019. 436–441 p.

7. Nieman DC. Clinical implications of exercise immunology. J Sport Heal Sci [Internet]. 2012;1(1):12–7.
8. Piepoli MF, Hoes AW, Agewall S, et al. European Guidelines on cardiovascular disease prevention in clinical practice. Eur Heart J. 2016;37(29):2315–2381.
9. Singh Chahar P. Physiological basis of Growth and Development among Children and Adolescent in Relation to Physical Activity. Am J Sport Sci Med. 2014;2(5A):17–22.
10. Dananjaya. Perbedaan VO 2 maks atlet bola basket bimasakti nikko steel Malang dengan atlet sepak bola arema indonesia. Universitas Muhammadiyah Malanng; 2012
11. Gomes De Araujo G, Manchado-Gobatto FDB, Papoti M, et al. Anaerobic and aerobic performances in elite basketball players. J Hum Kinet. 2014;42(1):137–47.
12. Plowman SA, Smith DL. Exercise physiology for health, fitness, and performance. 4th ed. China: Lippincott Williams & Wilkins; 2014. 717 p.
13. WHO. Global recommendation on physical activity for health. Switzerland: WHO; 2010.
14. Patel H, Alkhawam H, Madanieh R, et al. Aerobic vs anaerobic exercise training effects on the cardiovascular system . World J Cardiol. 2017;9(2):134.
15. U.S. Department of Health and Human Services. Physical activity guidelines for americans. 2nd ed. Rodgers AB, editor. U.S. Department of Health and Human Services; 2013. 56–63 p.
16. Habibi E, Dehghan H, Moghiseh M, et al. Study of the relationship between the aerobic capacity (VO2 max) and the rating of perceived exertion based on the measurement of heart beat in the metal industries Esfahan. J Educ Health Promot. 2014;
17. Bandyopadhyay A. Validity of cooper's 12-minute run test for estimation of maximum oxygen uptake in male university students. Biol Sport. 2015;32(1):59–63.
18. Penry J, Wilcox AR, Yun J. Validity and reliability analysis of cooper's 12 minute run and the multistage shuttle run in healthy adults. J Strenght Cond Res. 2011;25(3):597–605.
19. Das B. Estimation of maximum oxygen uptake by evaluating cooper 12-min run test in female students of West Bengal, India. J Hum Sport Exerc. 2013;8(4):1008–14.
20. Simpson RJ, Lowder TW, Spielmann G, et al. Exercise and the aging immune system. Ageing Res Rev [Internet]. 2012;11(3):404–20.
21. Gleeson M, Bishop N, Walsh N. Exercise immunology. Exercise Immunology. New York: Routledge; 2013. 342 p.
22. Buchan DS, Ollis S, Young JD, et al. The effects of time and intensity of exercise on novel and established markers of CVD in adolescent youth. Am J Hum Biol. 2011;23(4):517–26.
23. MacPherson REK, Hazell TJ, Olver TD, et al. Run sprint interval training improves aerobic performance but not maximal cardiac output. Med Sci Sports Exerc. 2011;43(1):115–22.
24. Minetto MA, Lanfranco F, Baldi M, et al. Corticotroph axis sensitivity after exercise: Comparison between elite athletes and sedentary subjects. J Endocrinol Invest [Internet]. 2007 Mar 31;30(3):215–23.
25. Cevada T, Vasques PE, Moraes H, et al. Salivary cortisol levels in athletes and nonathletes: A systematic review. Horm Metab Res. 2014;46(13):905–10.
26. Abdossaleh Z, Fatemeh A, Frozan K, et al. Leukocytes subsets is differentially affected by exercise Intensity. Int J Sport Stud [Internet]. 2014;4(2):246–53.
27. Bartlett DB, Shepherd SO, Wilson OJ, et al. Neutrophil and monocyte bactericidal responses to 10 weeks of low-volume high-intensity interval or moderate-intensity continuous training in sedentary adults. Oxid Med Cell Longev. 2017;2017.
28. Baffour-Awuah B, Addai-Mensah O, Moses M, et al. Differences in haematological and biochemical parameters of athletes and non-athletes. J Adv Med Med Res. 2017;24(12):1–5.
29. Sadegh M, Khoshnam E, Abedi HA. The effect of aerobic physical exercise on immune system andhs- crp in male athlete and non-athletes. 2012;6(12):3023–7.
30. Hamlin M, Draper N, Blackwell G, et al. Determination of maximal oxygen uptake using the bruce or a novel athlete-led protocol in a mixed population. J Hum Kinet. 2012;31(1):97–104.
31. VanBruggen MD, Hackney AC, McMurray RG, et al. The relationship between serum and salivary cortisol levels in response to different intensities of exercise. Int J Sports Physiol Perform. 2011;6(3):396–407.
32. Muscella A, Vetrugno C, Spedicato M, et al. The effects of training on hormonal concentrations in young soccer players. J Cell Physiol. 2019;234(11):20685–93.
33. Budde H, Voelcker-Rehage C, Pietrassyk-Kendziorra S, et al. Steroid hormones in the saliva of adolescents after different exercise intensities and their influence on working memory in a school setting. Psychoneuroendocrinology. 2010;35(3):382–91.
34. Hackney AC, Viru M, VanBruggen M, et al. Comparison of the hormonal responses to exhaustive

incremental exercise in adolescent and young adult males. Arq Bras Endocrinol Metabol. 2011;55(3):213–8.
35. Sato K, Iemitsu M, Katayama K, et al. Responses of sex steroid hormones to different intensities of exercise in endurance athletes. Exp Physiol. 2016;101(1):168–75.
36. Coutinho AE, Chapman KE. The anti-inflammatory and immunosuppressive effects of glucocorticoids, recent developments and mechanistic insights. Mol Cell Endocrinol [Internet]. 2011;335(1):2–13.
37. Ince LM, Weber J, Scheiermann C. Control of leukocyte trafficking by stress-associated hormones. Front Immunol. 2019;10(JAN):1–9.
38. Yeager MP, Pioli PA, Guyre PM. Cortisol exerts bi-phasic regulation of inflammation in humans. Dose-Response. 2011;9(3):332–47.
39. Besedovsky L, Born J, Lange T. Endogenous glucocorticoid receptor signaling drives rhythmic changes in human T-cell subset numbers and the expression of the chemokine receptor CXCR4. FASEB J. 2014;28(1):67–75.
40. Albayrak CD, Çiftçi S, Beylero M, et al. Association of immune parameters with stress hormone levels in elite sportsmen during the pre-competition. Int J Hum Sci. 2013;10(1):1412–20.
41. Nourshargh S, Alon R. Leukocyte Migration into Inflamed Tissues. Immunity [Internet]. 2014;41(5):694–707.
42. Huldani, Achmad H, Aryyad A, Putra AP, Sukmana BI, Adiputro DL, et al. Differences in VO2 max based on age, gender, hemoglobin levels, and leukocyte counts in Hajj prospective pilgrims in Hulu Sungai Tengah Regency, South Kalimantan. Syst Rev Pharm. 2020;11(4):9–14. . doi:10.31838/srp.2020.4.03.
43. Huldani , Siti Kaidah, Julia Kasab, Fauziah, Muhammad Hasan Ridhoni, Wafa Ahdiya. VO2 Max in River Beach communities in hst district by age, gender, and mobile immunity (neutrofil and limfosite). European Journal of Molecular & Clinical Medicine, 2020; 7(8): 1126-1132

Sys Rev Pharm 2020; 11(4): 306 - 312
A multifaceted review journal in the field of pharmacy
E-ISSN 0976-2779 P-ISSN 0975-8453

Research Reviews on Effect of Exercise on DAMP's, HMGB1, Proinflammatory Cytokines and Leukocytes

Huldani[1], Ilhamjaya Patellongi[2], Muhammad Nasrum Massi[3], Irfan Idris[4], Agussalim Bukhari[5], Agung Dwi Wahyu Widodo[6], Harun Achmad[7*]

[1]Department of Physiology, Faculty of Medicine, Lambung Mangkurat University, Banjarmasin, South Kalimantan, Indonesia
[2]Department of Physiology, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi, Indonesia
[3]Department of Medical Microbiology, Faculty of Medicine, University Hasanuddin, Makassar, South Sulawesi, Indonesia
[4]Department of Physiology, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi, Indonesia
[5]Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi
[6]Department of Microbiology, Faculty of Medicine, Airlangga University, Surabaya, East Java, Indonesia
[7*]Department of Pediatric Dentistry, Hasanuddin University, Makassar, South Sulawesi, Indonesia
Correspondence Author E-mail: haruntachmaden@gmail.com

Article History: Submitted: 23.01.2020 Revised: 20.03.2020 Accepted: 09.04.2020

ABSTRACT
Intensive exercise can induce pro and anti-inflammatory cytokines, which is clearly seen with an increase in leukocytes in the circulation DAMPs trigger massive cytokine release including tumor necrosis factor (TNF-α), interleukin (IL) -1, IL-6, IL-8, IL-12 and IFN types I and II. HMGB1 in human monocyte culture stimulates the release of some TNF-α, IL-1, IL-6, IL-8 and inflammatory protein macrophages (MIP)-1.Exercise can cause a high inflammatory response by increasing proinflammatory and anti-inflammatory cytokines IL6, IL8, IL10, IL1β, and TNF-α). In Men IL1β and TNF- higher levels than women, both at baseline values and on the results of the examination after exercise. Exercise with an exercise program can increase IFN, TNF levels-α, IL-6, IL-8, IL1β, VEGF and MCP. In aerobic exercise there were no significant changes in TNF levels-and IL-8 but there is an increase in the number of neutrophils. Intensity and aerobic exercise in experimental animals increased TNF levels-and IL-6 in High Intensity Interval Training (HIIT) and Moderate Intensity Training (MIT) while in short-term aerobic exercise the HMGB1 level decreased. Conclusion: Exercise can effect DAMPs, HMGB1, proinflammatory cytokines, and blood leukocytes depending on variation, duration, intensity, type of exercise, and research subjects.
Keywords: HmgbT, Proinflammatory Cytokines, Leukocytes
Correspondence:
Harun Achmad
Department of Pediatric Dentistry, Hasanuddin University, Makassar, South Sulawesi, Indonesia
E-mail: haruntachmaden@gmail.com
DOI: 10.5530/srp.2020.4.44

INTRODUCTION

Physical exercise has 4 basic components, namely cardiac and pulmonary exercise (cardiopulmonary), muscle strength, flexibility and body composition.[1] Intensive exercise can induce pro-cytokines or anti-inflammatory, which is clearly seen with an increase in leukocytes in the circulation. However, it is known that neutrophils were one of the first immune cells released to respond to trauma, especially those caused by bacteria.[2] After doing exercise, the concentration of neutrophils in the blood will increase to 100 fold. While cytokines and chemokines induced by training activities include interleukin 6, 8, 10 and monotactic protein monocytes (MCP) -1.[3]The researchers agree that the athlete must examine also check the levels of several cytokine components in the process of checking the detection of chronic inflammation.[4]

Neutrophils play an important role in muscle tissue damage in the acute phase of muscle injury, whereas monocytes / macrophages regulate subsequent tissue regeneration. Neutrophils and monocytes / macrophages secrete various cytokines. Endothelial cells, pericytes, fibroblasts, neutrophils and monocytes / macrophages may all contribute to the expression of global cytokines in skeletal muscle.[3]

Muscle damage and injury is one of the risks when exercising, especially for athletes. One marker of muscle damage is creatinine kinase, which is released in response to damage to skeletal muscle and heart muscle in myocardial infarction. Despite its limitations, creatinine kinase levels are still used as biomarkers for muscle damage. After the biomarkers are released into the circulation, immune cells at the tissue level or native immune cells will migrate to the damaged target tissue and differentiate into mature proinflammatory macrophages and function to phagocyte, clean debris and degenerate damaged tissue. The mature macrophages will also release several growth factors, cytokines and other molecules as signals to start the inflammatory process. During this inflammatory process, macrophages turn into anti-inflammatory components and release growth factors and silkoin with different types and functions from before to support the healing process.[4]

Muscle contraction directly induces the release of IL6 which is part of chemokine and plays a role and regulation of muscle growth.6 IL6 has a positive effect in glucose uptake and fat oxidation, besides, in its role as an anti-inflammatory cytokine, IL6 weakens the production of TNF alpha and IL1 beta where both have been known to form in the acute phase reaction and during cell proliferation.[7]

People who are overweight (obese) have higher levels of IL6 and TNF alpha than people with normal weight. This is because the accumulation of triglycerides in adiposity causes adiposity hypertrophy so that there will be an increase in pro-inflammatory cytokines, one of which is neutrophils which are the first immune cells respond when inflammation occurs by infiltrating into the adipose tissue and then stimulating the entry of M1 macrophages. These macrophages trigger an increase in IL6 and TNF alpha production.[8]

It is known that moderate intensity exercise (Moderate Intensity Training or MIT) is effective in reducing body fat. This low level of fat will prevent fat cell damage and the

163 --- Olahraga & Sistem Imun

possibility of cell hypoxia, so that it will reduce pro-inflammatory cytokines, namely IL6 and TNF, through increased adiponectin secretion and increased anti-inflammatory cytokines.[8]

While exercise with heavy intensity (High Intensity Interval Training or HIIT) is known to be effective in increasing the lipid profile and the release of anti-inflammatory sitkoin because when someone does HIIT there is a muscle contraction that causes mitochondrial activity to be maximized in enzymatic reactions. This will increase glucose uptake in skeletal muscle which will eventually also cause an increase in adiponectin secretion.[8]

A study was conducted on 39 obese mice to observe differences in levels of alpha TNF and IL6 after exercise for 6 weeks with a frequency of 4 times a week between groups of rats with high intensity exercise (HIIT), groups of rats with moderate intensity training (moderate intensity training or MIT) and control groups that don't do the exercise. The results showed that the MIT and HIIT group had significantly higher alpha TNF levels than the control group, but there were no significant differences in the alpha TNF level between the MIT and HIIT groups. Whereas IL-6 levels in the HIIT group were significantly lower than the MIT and control groups.[8]

Research by Hildae et al. Of respondents with chronic inflammatory disease (type 1 diabetes, fibrosis cysts, and chronic obstructive pulmonary disease). The results show that groups with chronic inflammatory disease are more likely to trigger different inflammatory responses (for example, the inflammatory response becomes excessive after acute exercise and becomes weak after exercise) compared to the healthy group. Inflammatory marker levels, especially IL-6, and T cells, total leukocytes and lymphocytes, will remain high with a longer duration to the recovery phase after acute exercise in patients with chronic inflammatory diseases than in healthy individuals. Other than that,in her journal that was approved by previous studies proving a systemic endurance exercise program in patients with chronic heart failure and type 2 diabetes mellitus.[9]

Another study conducted on a group of respondents who did an exercise program for 4 weeks, showed that IFN gamma and TNF alpha levels in the group did not have a significant difference between before and after 4 weeks of training. In their journal, Marques et al said that the results of various studies on the relationship of exercise with cytokine levels were not so consistent, not all studies showed an increase in cytokines after exercise. Like a study of a group that did 32 weeks of training, the results actually showed no significant effect on cytoin levels in some older respondents.[10]

LaVoy et al in his journal stated that the results of studies consistently show that acute aerobic exercise in humans does not change the cytokine activity of T cells and the strength of exercise does not change the levels of TNF alpha and IFN gamma in individuals with type 2 diabetes. However, the results of Tierra et al. showed that swimming training for 12 weeks caused an increase in gamma IFN and TNF alpha in mice that were the study subjects. And the same study by Lamprecht et al with research subjects in the form of horses showed the results of increased levels of gamma IFN. These studies all show different and inconsistent results. This could be due to differences in types, duration, intensity and research subjects.[10]

Strength training induces leukocytosis especially neutrophils in the systemic circulation, damage to muscles and internal organs and immune suppression.[11] In contrast to the study of Huldani et al 2020 showed there were no significant differences in the number of leukocytes in the fitter and fatigue groups, with the average number of leukocytes in the group with VO2 max fit is 7.83 thousand / µl and 7.27 thousand / µl in the less fit group. This study was also supported by Tenorio in 2014 regarding the relationship of leukocyte counts, nutritional status, and fitness status in adolescents, which actually showed a negative correlation between leukocyte counts and adolescent fitness status.[12] Various studies have shown that the effect of increasing neutrophils after strength training lasts several hours longer. However, cytokine response is not significant during and after intensive training with short duration. The accumulation of inflammatory cytokines, neutrophils and macrophages in the organs triggers the formation of tissue damage or organ dysfunction, not only muscle, but also the kidneys, liver and intestine.[13]

Research also shows that the magnitude of the IL6 response after strength training depends on decreasing cellular energy and increasing heat stress which is then related to stress hormones. This response will be suppressed by an increase in energy supply and cooling interventions of the body. According to Katsuhiko in his journal, exercises conducted at night will induce more IL6 release than morning exercises.[11]

Research by Richard et al of healthy young adults who underwent random aerobic exercise (cycling, swimming, etc.) for 12 weeks. The results showed a 15% increase in VO2 max and an increase in free fat mass in the group that did the exercise program and this did not occur in the control group who did not do the exercise. The hypothesis in this study is that exercise will reduce the induction of the release of TNF alpha, IL6 and TLR4. But apparently the results of the hypothesis are wrong. However, post hoc analysis shows that exercise triggers IL6 and TNF alpha responses to lipopolysaccharide stimulation, this is consistent with the possible positive effects of aerobic exercise on health.[13]

Alarmin is an endogenous molecule that plays a role in the physiological function of homeostasis, but can be produced quickly as a result of cell damage due to stress, infection or trauma. There are several types of alarmin based on the location of the cellular compartment where it is located. Aalarmin which is in the nucleus is called High Mobility Group Box-1 (HMGB1), it binds to DNA. HMGB1 circulating in circulation forms heterocomplex with 12 CXC motif chemokines (CXCL12).[5] Activated HMBG1 will bind to PRR in immune cells to contribute to proinflammatory signals. Inducing cytokines, such as the release of TNF alpha, TLR-4 and the CXC receptor 4 chemokine receptor (CXCR4). Then, it is CXCR4 that induces microglial activation, phosphorylation of MAPK p42 / 44 and expression of interleukin 6 and TNF alpha.[14]

A person who exercises with severe intensity has the possibility to experience injury or muscle breakdown, although it is rare, or life-threatening conditions such as rhabdomyolisis.3 In the case of such an injury, there will be a condition called secondary inflammatory response as a result of the release of inflammatory factors intracellular to extracellular parts. This will then cause an endogenous danger signal called damage-associated molecular patterns (DAMP). One of the proteins of this DAMP is high mobility group box 1 (HMGB1).[12] It is released as a danger signal of damage to muscle cells so that it activates and triggers the mobilization of immune cells toward the target location. HMGB1 levels will return to their original concentration after 30 minutes of rest after exercise.

Not all exercises can trigger a meaningful increase in HMGB1 systemically. One of the studies that looked at HMGB1 levels in plasma respondents who did exercise in the form of bicycle racing as far as 1200 km, obtained results that were exactly the opposite of the results of other studies. Although there are technical errors in plasma examination and the influence of biological phenomena in this study cannot be ruled out.[3]

RESEARCH ON HUMAN

Some research comparisons based on the subject, training methods and research results based on acute exercises:

No	Title (Author)	Research subject	Method of Subject Training	Conclusions / Research Results
1.	The effects of acute and chronic exercise on inflammatory markers in children and adults with a chronic inflammatory disease: a systemic review (Hilde E. Ploeger, Takken Team, Mathieu HG de Greef, Brian W. Timmons, 2009)	Adult and child groups, each with chronic inflammatory disease (type 1 diabetes mellitus patients, fibrosis cysts and chronic obstructive pulmonary disease)	7 children doing acute training, 8 adults doing acute training, 5 other adults doing chronic strength training, 1 person doing resistance training (weight training)	• An exercise program can reduce chronic inflammation in some patients in the study subjects. However, if only doing one single exercise will actually cause a worse inflammatory response. Inflammatory response arising from exercise training can be higher, depending on the type and severity of the disease, as well as the frequency, duration and intensity of the exercise performed.
2.	Changes in cytokine levels after prolonged and repeated moderate intensity exercise in middle-aged men and women (R. Terink, CCWG Bongers, BF Witkamp, M. Mensink, TM Eijsvogels, JMT Klein Gunnewiek, MTE Hopman, 2018)	50 men (mean age 58.9 ± 9.9 years) and 50 women (average age 50.9 ± 11.2 years).	The research subject groups were monitored for 4 consecutive days and had to walk for about 9 hours each day at their own pace. The first blood sample is taken one to two days before the exercise begins as a reference value or baseline, the next sample is taken every day immediately after the exercise is completed.	• All cytokine concentrations observed after exercise (IL6, IL8, IL10, IL1 beta, and TNF alpha) experienced an increase in baseline values (P> 0.001). Then the concentration decreased from the first day to the second day (P <0.01). • Baseline values of cytokines in the group of men and women have different. And IL1 beta and TNF alpha are the 2 types of cytokines with the highest levels in the group of male respondents, both at baseline values and on the results of the examination after exercise. • Exercise induces an increase in cytokines, but these levels will go down in the following days while still doing the same intensity and training load

Some research comparisons by subject, training methods and research results by type of exercise:

No	Title (Author)	Research subject	Method of Subject Training	Conclusions / Research Results
1.	The effect of a fourweek exercise	10 taekwondo athletes were male,	All research subjects underwent	• The levels of gamma

	program on the secretion of IFN-γ, TNF-α, IL-2 and IL-6 cytokines in elite Taekwondo athletes (Oktay Kaya, 2016)	with an average age of 20.67 ± 0.24 years and weight 65.45 ± 1.69 kg, in good health, studying at a high school level Physical and Sports Education, Selcuk University, Konya, Turkey.	taekwondo training programs every day for 4 weeks. The exercise program starts with warming up for 20 minutes, each exercise is repeated 3 times, and ends with cooling.	IFN and alpha TNF did not differ significantly between before and after the 4 week exercise program. • The highest IL6 level was found in the fatigue phase after exercise (P <0.05). • A 4-week exercise program resulted in a decrease in IL6 levels (P <0.05)
2.	Effect of Intense Exercise on Inflammatory Cytokines and Growth Mediators in Adolescent Boys (and Nemet, Youngsun Oh, Ho-Seong Kim, MaryAnn Hill, Dan M. Cooper, 2002)	11 healthy men of high school age, ranging from 14 to 18.5 years old, took 1.5 hours of single wrestling	Subjects must attend a single and special wrestling exercise program for 1.5 hours.	• There was a significant decrease in anabolic mediator after exercise, i.e. total IGF1, IGF1 bound and Insulin. Whereas free IGF-1 does not change. • An increase in proinflammatory cytokines after exercise, namely IL6. Alpha TNF and IL1 beta.
3.	Circulating Inflammatory Cytokine Responses to Endurance Exercise in Female Rowers. (Jürimäe, J., Vaiksaar, S., & Purge, P., 2018).	Fifteen female rowers (18.3 ± 1.6 years; 172.0 ± 5.0 cm; 67.5 ± 8.8 kg; maximum oxygen consumption [VO2 max]: 47.2 ± 7.9 mL -1 kg-1)	All study subjects completed 1 hour endurance exercise (distance: 12.1 ± 1.1 km; energy expenditure [EE]: 639 ± 69 kcal; heart rate: 151 ± 7 bealsmin-1; intensity: 79.6 ± 3.5% of the second ventilation turning point).	• Cardiorespiratory fitness as measured by VO2 max correlates with changes in IL-6 (r = -0.55; P <0.05) I • Improvement (P <0.05) in IL-6, IL-8, VEGF and MCP

Some research comparisons by subject, training methods and research results based on aerobic exercise:

No	Title (Author)	Research subject	Method of Subject Training	Conclusions / Research Results
1.	Aerobic Exercise Training and Inducible Inflammation: Results of a Randomized Controlled Trial in Healthy, Young Adults (Richard P. Sloan, PhD; Peter A. Shapiro, MD; Paula S. McKinley, PhD; * Matthew Bartels, MD; † Daichi Shimbo, MD; Vincenzo Lauriola, MS; Wahida Karmally, RD; Martina	119 young adults (ages 20-45 years), healthy, not smoking, low activity, do not have good exercise habits.	All research subjects took part in running for 2 weeks then underwent the first blood sample (T1). Individuals who meet the first program can go on to the next session for 12 weeks (aerobic exercise program) and after that a second sample (T2) is taken. Then, given 4 weeks to not do the exercise, only the third sampling (T3)	• There were no changes in the inflammatory markers even though during exercise there was a maximum increase in oxygen consumption by fifteen percent. • Aerobic exercises with different longitudinals also produce different polysaccharide effects in inducing TNF alpha san IL6, conditions in T1 and T2 trigger polysaccharides to increase their induction of the release of TNF alpha (P = 0.041) and IL6 (P = 0.11), and significantly the phase between T2 to T3 triggers polysaccharides to reduce their induction in the release of TNF alpha (P = 0.007)

	Pavlicova, PhD; C. Jean Choi, MS; Tse-Hwei Choo, MS; Jennifer M. Scodes, MS; Pamela Flood, MD; 2 Kevin J. Tracey, MD, 2018)		was conducted.	and IL6 (P <0.001) • There were no significant changes in TNF alpha and IL6 between each phase when lipopolysaccharide levels were 0.0 ng / ml.
2.	Effects of mild and moderate aerobic exercise on levels of interleukin 8 and total neutrophils in adolescents (Huldani, 2016)	31 male students of SMAN 1 Banjarbaru, with an age range of 15-18 years, physically fit, do sports at least once a week at least jogging for 30 minutes, cooperative, not smoking, not taking drugs that affect the number of neutrophils and levels IL8 at least 2 days before blood draw, normal body mass index (20-25), VO2 max value > 38.4	9 people underwent mild aerobic exercise, 12 people underwent moderate aerobic exercise, and 10 people did not undergo training or as controls	• An increase in the number of neutrophils after doing aerobic exercise, can be seen from the average number of neutrophils in the mild and moderate aerobic group compared to the control group. • There was no difference between the mild aerobic and control groups (P = 0.519). • There was a difference between the moderate aerobic group and the control group (P = 0,000) • There was no difference in the number of neutrophils between the group of adolescents who did light aerobic exercise with the control group (P = 0.519) • Moderate aerobic exercise causes an increase in the number of neutrophils in the group of study subjects.

RESEARCH ON ANIMALS

Some research comparisons based on subject, training methods and research results:

No	Title (Author)	Research subject	Method of Subject Training	Conclusions / Research Results
1.	Effect of High Intensity Interval Training (HIIT) and Moderate Intensity Training (MIT) on TNF-α and IL-6 levels in rats (Hadiono and BM Wara Kushartanti, 2018)	Thirty Nine white Rattus norvegicus rats wistar strain, male sex, aged 2-3 months with fat body weight (> 160 grams).	Rats were divided into three groups. 13 control groups without any exercise intervention, 13 were given high intensity interval training (HIIT) and 13 were undergoing moderate intensity physical training (MIT)	• Blood test results showed that the group that had done HIIT and MIT had significantly higher levels of TNF alpha compared to the control group (P = 0.003 and P = 0.001, respectively). • Both groups undergoing HIIT and MIT training did not have significant differences in alpha TNF levels. • The group undergoing HIIT had the lowest IL-6 levels compared to the MIT and control groups.
2.	Aerobic training normalizes autonomic dysfunction, HMGB1 content, microglia activation	SHR (spontaneously hypertensive rat) mice and Wistar-Kyoto (TWK) mice, aged 12 weeks, were	SHR and TWK mice were divided into two groups. The first group did not undergo training (sedentary	• Short-term aerobic exercise reduced HMGB1 levels in the paraventricular nucleus (NPV), cerebrospinal fluid (CSS (P <0.01) and plasma (P <0.01) in the SHR rat group.

	and inflammation in the hypothalamic paraventricular nucleus of SHR (Gustavo Santos Masson, Anand R. Nair, Pedro Paulo Silva Soares, Lisete Compagno Michelini and Joseph Francis, 2015)	placed at room temperature of 22 degrees Celsius and regulated light cycles 12 hours bright and 12 hours dark, accompanied by free access to food and water.	rats) and the second group underwent moderate intensity training (50-60% of maximum training capacity), carried out as many as 5 days per week, duration of 1 hour for each exercise, routine for 2 weeks.	• HMGB1 expression in NPV in SHR mice was higher than in TWK. • Doing aerobic exercise can reduce HMGB1 levels in NPV to normal levels in the SHR group (P <0.01). • However, HMGB1 levels in NPV in the TWK group were not significantly affected by aerobic exercise.

DISCUSSION

In the table above it can be seen that the results of acute exercise with exercise training programs can cause a high inflammatory response with an increase in proinflammatory and anti-inflammatory cytokines (IL6, IL8, IL10, IL1 beta, and TNF alpha). The levels of IL1 beta and TNF alpha are higher in men than women, both at baseline and after exercise. Exercise with an exercise program can increase levels of IFN, TNF alpha, IL-6, IL-8, IL1B, VEGF and MCP. In aerobic exercise there was no significant change in TNF alpha and IL-6 levels but there was an increase in neutrophil counts.

Previous studies have reported that prolonged single endurance exercise can cause acute increases in various variants of inflammatory cytokines, such as IL-2, IL-6, IL-8, IL-8, IL-10, IL-1β, TNF-α , gamma interferon (IFN-γ), monocyte-1 monocyte protein (MCP-1) and granulocyte-macrophage colony stimulating factors in male endurance athletes. However, there is only very limited information available for physically active women, where a single aerobic exercise has been reported to have no effect or can cause an increase in post-exercise in some inflammatory cytokines. The most studied inflammatory cytokines are IL-6, TNF-α and IL-1β, which usually increase as a result of a single training session that produces an acute inflammatory response. However, other investigations did not find changes in these inflammatory cytokine levels after acute exercise.[9]

Overall, DAMPs trigger the release of massive cytokines including TNF-α, IL-1, IL-6, IL-8, IL-12 and IFN types I and II. This mediator strengthens activation, maturation, proliferation, and recruitment of immune cells at the site of trauma, causing indirect activation of innate and adaptive immune cells such as DC or T cells.[9]

Exposure to HMGB1 in human monocyte culture stimulates the release of several proinflammatory cytokines including tumor necrosis factor (TNF), interleukin (IL) -1, IL-6, IL-8 and inflammatory protein macrophages (MIP) -1.The kinetic response to TNF release mediated by HMGB1 and LPS is very different. The release of TNF induced by HMGB1 is biphasic with the second wave being delayed, whereas the release of TNF mediated by LPS only occurs in the initial monophasic mode.[9,10,11,12]

CONCLUSION

Exercisecan affect DAMPs, HMGB1, proinflammatory cytokines, and blood leukocytes depending on variation, duration, intensity, type of exercise, and research subjects.

REFERENCES

1. Huldani, Asnawati, Aulladina D, Amilia, FR, Nuarti N, Jayanti R. (2019). Abdominal Circumference, Body Fat Percent, and VO2 Max in Pilgrims of Hulu Sungai Tengah Regency. Journal of Physics: Conference Series. 1374 (1). https://doi.org/10.1088/1742-6596/1374/1/012058.
2. Huldani, Sukmana BI, Pujiningtyas A, Savitri E, Fauziah, Nihayah U. (2019). Cellular Immunity of River Water Consumption and Bandarmasih Municipal Waterworks Consuments. Indian Journal of Public Health Research and Development. 10 (7): 789-94. DOI: http://dx.doi.org/10.5958/0976-5506.2019.01674.7.
3. Goh J, Behringer M. (2018). Exercise alarms the immune system: a HMGB1 perspective. Cytokine. 110: 222-5. https://doi.org/10.1016/j.cyto.2018.06.031.
4. Lee EC, Fragala MS, Kavouras SA, Queen RM, Pryor JL, & Casa DJ. (2017). Biomarkers in sports and exercise: tracking health, performance, and recovery in athletes. Journal of strength and conditioning research. 31 (10): 2920. DOI: 10.1519 / JSC.0000000000002122.
5. Peake JM, Gatta PD, Suzuki K, Nieman DC. (2015). Cytokine Expression and Secretion by Skletal Muscle Cells: Regulatory Mechanisms And Exercise Effects in Exercise Immunology Review. EIR 21 p- 8-25.
6. Nemet D, Oh Y, Kim HS, Hill M, Cooper DM. (2002). Effect of intense exercise on inflammatory cytokines and growth mediators in adolescent boys. Pediatrics. 110 (4): 681-689. DOI: https://doi.org/10.1542/peds.110.4.681.
7. Terink, R., Bongers, CCWG, Wilkamp, RF, Meusink, M., Eijsvogels, TM, Klein GJMT, Hopman. (2018). MTE Changes in cytokine levels after prolonged and delayed moderate intensity exercise in middle-aged men and women. Translational Sports Medicine. 1 (3): 110-9. DOI: https://doi.org/10.1002/tsm2.23.
8. Hadiono, Kusbariani BMW. (2018). Effects of High Intensity Interval Training (HIIT) and Moderate

Intensity Training (MIT) on TNF-α and Il.-6 in Rats. Advances in Health Sciences Research (AHSR). 7: 87-90. http://eprints.uny.ac.id/cn/eprint/40015.
9. Ploeger HE, Takken T, De Greef MH, Timmons BW. (2009). The effects of acute and chronic exercise on inflammatory markers in children and adults with a chronic inflammatory disease: a systematic review. Exerc Immunol Rev. 15 (1): 6-41. http://hdl.handle.net/11370/d1c80d12-e6c3-4648-b726-84840952f272.
10. Rich O. (2016). Effects of a four-week exercise program on the secretion of IFN-γ, TNF-α, Il. 2 and IL-6 cytokines in elite Taekwondo athletes. Biomedical reports. 5 (3): 367-70. https://doi.org/10.3892/br.2016.730.
11. Suzuki K. (2018). Cytokine response to exercise and its modulation. Antioxidants. 7 (1): 17. https://doi.org/10.3390/antiox7010017.
12. Huldani, Achmad H, Arsyad A, Putra AP, Sukmana BI, Adiputro DL, Kasab J. (2020). Differences in VO2 Max Based on Age, Gender, Hemoglobin Levels, and Leukocyte Counts in Hajj Prospective Pilgrims in Hulu Sungai Tengah Regency, South Kalimantan. SRP. 11 (4): 09-14.doi: 10.31838/srp.2020.4.02
13. Sloan RP, Shapiro PA, McKinley PS, Bartels M, Shimbo D, Lauriola V, et al. (2018). Aerobic exercise training and inducible inflammation: Results of a randomized controlled trial in healthy, young adults. Journal of the American Heart Association. 7 (17). https://doi.org/10.1161/JAHA.118.010201.
14. Masson GS, Nair AR, Silva Soares PP, Michelini LC, Francis J. (2015). Aerobic training normalizes autonomic dysfunction, HMGB1 content, microglia activation and inflammation in the hypothalamic paraventricular nucleus of SHR. American Journal of Physiology-Heart and Circulatory Physiology. 309 (7). https://doi.org/10.1152/ajpheart.00349.2015.
15. Huldani H. (2016). Effects of Mild and Moderate Aerobic Exercise on Interleukin 8 Levels and Neutrophil Amounts in Adolescents. Periodical Medicine. 12 (1): 61-7.http://dx.doi.org/10.20527/jbk.v12i1.357.
16. Achmad, H. Khairunnisa, P. Mardiana, Karni Aulia, A. (2018). Potentially Of Extracted Papua's Anthill (*Myrmecodia pendans*) As Antitumor To Emphasis The Expression Of Vascular Endothelial Growth Factor Cell Burkitt's Lymphoma Cancer, Asian Journal. of Microbiol. Biotech. Env Sc. © Global Science Publications pp. 108-112, Vol. 20, No. (1). ISSN-0972-3005.
17. Jürimäe, J., Vaiksaar, S., Purge, P. (2018). Circulating Inflammatory Cytokine Responses to Endurance Exercise in Female Rowers. International Journal of Sports Medicine..Med ISSN 0172-4622DOIhttps://doi.org / 10.1055 / a-0723-4421.
18. Ahmad H. Horax S, Ramadhany S, et.al. (2019). Resistivity of Ant Nest (*Myrmecodia pendans*) On Ethanol Fraction Burkitt's Lymphoma Cancer Cells (Invitro) Through Interleukin 8 Angiogenesis Obstacles (Il-8). Journal of International Dental and Medical Research _ ISSN 1309-100X. Vol 12 No. (2) pp.516-523.
19. Mickail V,Antoine R, Karim A. (2018). Trauma-Induced Damage Associated Molecular Patterns-Mediated Remote Organ Injury and Immunosuppression in the Acutely Ill Patient. The Immunol Front. 2018; 9: 1330. Doi10.3389 / fimmu.2018.01330 MCID: PMC6013556 PMID: 29963048.
20. Achmad, H. (2018). Apoptosis Induction (Caspase-3, -9) and Human Tongue Squamous Cell Carcinoma VEGF Angiogenesis Inhibition using Flavonoids's Ethyl Acetate Fraction of Papua Ant Hill (*Myrmecodia pendans*) SP-C. "). Journal of International Dental and Medical Research. ISSN 1309-100X. (Scopus Index). Volume 11 Number (1). pp. 276-284.
21. Huan Y, Haichan W, Sangeeta SC, Ulf A. (2015). High Mobility Group Protein Box 1 (HMGB1): The Prototypical Endogenous Danger Molecule. MOL MED 21 (SUPPLEMENT 1), S6-S12.
22. Dashottar, S., Singh, A.K., Sahag, V., Sunita, Singh, R. Unusual case of congenital aneurysm of proximal pulmonary artery causing lung collapse (2015) Journal of Cardiovascular Disease Research, 6 (1), pp. 31-36. DOI: 10.5530/jcdr.2015.1.6
23. Achmad H, Horax S, Ramadhany S, Rieuwpassa IE, Sari M, Handayani H, Singgih MF, Sugiharto S. (2019). Anti-Cancer and Anti-Proliferation Activity of Ethyl Acetate Extract From Ant Nest (Myrmecodia pendans) In Burkitt's Lymphoma Cancer Cells. Pesquisa Brasileira em Odontopediatria e Clínica Integrada. ISSN 1519-0501, 19 (1): e4325.