KESAN SENAMAN TAI CHI JANGKAMASA PANJANG KE ATAS PROFIL KARDIOVASKULAR DAN STATUS OKSIDATIF DI KALANGAN DEWASA TUA

AZNI BINTI RABU

TESIS YANG DIKEMUKAKAN UNTUK MEMPEROLEH IJAZAH
SARJANA SAINS PERUBATAN

FAKULTI PERUBATAN
UNIVERSITI KEBANGSAAN MALAYSIA
KUALA LUMPUR

2010

PENGAKUAN

Saya akui karya ini adalah hasil kerja saya sendiri kecuali nukilan dan ringkasan yang setiap satunya telah saya jelaskan sumbernya.

18 Mei 2010

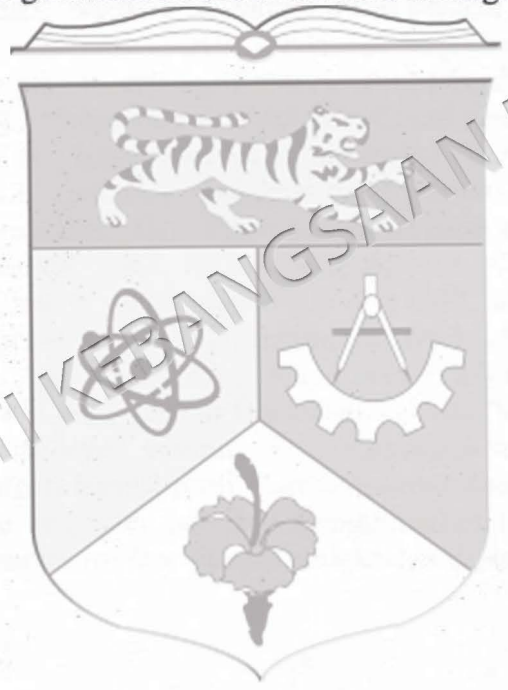
AZNI BINTI RABU
P 35571

PENGHARGAAN

Sekalung penghargaan dan ucapan terima kasih yang tidak terhingga diucapkan kepada penyelia utama, Profesor Madya Dr. Noor Aini Abdul Hamid yang telah banyak membantu dan memberi tunjuk ajar kepada saya sepanjang kajian ini dilakukan. Tidak dilupakan juga penyelia bersama, Profesor Dr. Wan Zurinah Wan Ngah yang telah banyak memberi sokongan dan galakan kepada saya.

Terima kasih juga kepada semua kakitangan Jabatan Biokimia Fakulti Perubatan Universiti Kebangsaan Malaysia, kakitangan Jabatan Hematologi dan jabatan Patologi Kimia Hospital Kuala Lumpur serta rakan-rakan seperjuangan yang telah banyak membantu saya dalam menyiapkan kajian ini.

Setinggi-tinggi penghargaan juga disampaikan kepada Kementerian Sains, Teknologi dan Inovasi (MOSTI) kerana menyokong kajian ini dengan geran IRPA 06-02-02-0017/PR0008/09-02. Saya juga ingin merakamkan jutaan terima kasih kepada semua ahli keluarga yang sentiasa berada di sisi serta dorongan yang diberikan.



ABSTRAK

Cara hidup sedentari dikatakan mempunyai kaitan rapat dengan peningkatan terhadap berlakunya pelbagai penyakit kronik seperti penyakit kardiovaskular dan diabetis melitus di kalangan dewasa tua. Manakala, senaman pula dilaporkan dapat meningkatkan penghasilan radikal bebas yang seterusnya menyebabkan ketidakseimbangan dalam status oksidatif. Tujuan kajian ini adalah untuk menentukan kesan senaman Tai Chi jangkamasa panjang ke atas profil kardiovaskular dan status oksidatif di kalangan dewasa tua. Kajian kes kawalan ini telah dijalankan ke atas 200 individu sihat berumur 45 tahun ke atas, terdiri daripada kumpulan kawalan sedentari (n=100) dan individu yang telah melakukan senaman Tai Chi lebih dari 2 tahun (n=100). Profil kardiovaskular ditentukan melalui kadar denyutan jantung, tekanan darah dan profil lipid. Peroksidasi lipid dan glikosilasi diukur melalui penentuan aras malondialdehid (MDA) dan 'advanced glycosylation end product' (AGE) masing-masing manakala kerosakan oksidatif DNA ditentukan melalui pengasaian komet. Status antioksidatif dikaji dengan mengukur aktiviti enzim antioksidan superoksid dismutase (SOD), katalase (CAT), glutation peroksidase (GPx) dan kepekatan vitamin antioksidan A, C dan E. Profil kardiovaskular menunjukkan kadar denyutan jantung, tekanan darah sistol dan diastol yang lebih rendah ($p< 0.05$) dalam kumpulan Tai Chi. Kepekatan HDL dan nisbah HDL/kolesterol lebih tinggi dalam kumpulan Tai Chi ($p<0.05$), manakala tiada perubahan yang signifikan pada aras kolesterol, trigliserida dan LDL. Tiada perbezaan pada aras MDA, aras AGE dan peratus kerosakan oksidatif DNA dalam kumpulan Tai Chi berbanding kawalan. Walau bagaimanapun, enzim antioksidan SOD dan CAT adalah lebih tinggi secara signifikan dalam kumpulan Tai Chi berbanding sedentari ($p<0.05$), manakala enzim GPx pula adalah lebih rendah ($p<0.05$). Kepekatan vitamin A adalah lebih rendah manakala vitamin C lebih tinggi dalam kumpulan Tai Chi ($p<0.05$). Tiada perbezaan ditunjukkan dalam kepekatan vitamin E. Kesimpulannya, senaman Tai Chi jangkamasa panjang memperbaiki profil kardiovaskular dengan meningkatkan HDL dan menurunkan kadar denyutan nadi dan mengurangkan tekanan oksidatif dengan merangsang penyesuaian enzim dan vitamin antioksidan dalam tubuh badan.

EFFECT OF LONG TERM TAI CHI EXERCISE ON CARDIOVASCULAR PROFILE AND OXIDATIVE STATUS AMONG OLDER ADULTS

ABSTRACT

Sedentary life is known to be associated with increase in the incidence of chronic diseases such as cardiovascular diseases and diabetes mellitus in older adults. Exercise on the other hand, has been reported to increase free radical production resulting in an imbalance in oxidative status. The aim of this study was to determine the effect of long term Tai Chi exercise on cardiovascular profile and oxidative status amongst older adults. A case control study was done on 200 healthy adults aged 45 years and above consisting of a sedentary control group (n=100) and those who had been practicing Tai Chi for more than 2 years (n=100). Cardiovascular profile was determined by the heart rate, blood pressure and lipid profile. Lipid peroxidation and glycosylation were measured by determining the levels of malondialdehyde (MDA) and advanced glycosylation end products (AGE) respectively, while DNA oxidative damage was measured by comet assay. Antioxidative status was determined by measuring the activities of the antioxidant enzymes superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx) and concentration of the antioxidant vitamins A, C and E. The cardiovascular profile showed significant lowering of the heart rate and systolic and diastolic blood pressure ($p<0.05$) in the Tai Chi group. HDL and HDL/cholesterol ratio were higher in Tai Chi group ($p<0.05$), while no significant change in cholesterol, triglyceride and LDL concentrations was observed. There was no difference in the MDA level, AGE level and percentage of DNA oxidative damage in the Tai Chi group compared to control. However, the antioxidant enzymes SOD and CAT were significantly higher in the Tai Chi group compared to the sedentary group ($p<0.05$), while GPx was significantly lower ($p<0.05$). The vitamin A concentration was significantly lower, whereas vitamin C concentration was higher in the Tai Chi group ($p<0.05$). No difference was observed in the vitamin E concentration. In conclusion, long term Tai Chi exercise improved cardiovascular profile by increasing HDL concentration and decreasing heart rate and reduced oxidative stress by stimulating adaptation in antioxidant enzymes and vitamins in the body.

KANDUNGAN

SENARAI JADUAL

SENARAI ILUSTRASI

SENARAI SINGKATAN

ALP	Alkalin fosfatase
ALT	Alanin transaminase
LDL	Lipoprotein ketumpatan rendah
HDL	Lipoprotein ketumpatan tinggi
WBC	Sel darah putih
RBC	Sel darah merah
DNA	Asid deoksiribonukleik
ELISA	*Enzyme-Linked Immuno Sorbent Assay*
HPLC	*High Performance Liquid Chromatography*
HEPES	Asid 4-(2-hidroksietil)-1-piperazinetanasulfonik
UV	*Ultraviolet*
SPSS	*Statistical Package for Social Sciences*
Hb	Hemoglobin
FBC	*Full blood count*
LFT	Ujian fungsi hepar
PR	Profil renal
FBS	*Fasting blood sugar*

SENARAI SIMBOL

%	peratus
&	dan
<	kurang daripada
g	gram
mg	milligram
kg	kilogram
µg	mikrogram
rpm	putaran per minit
°C	darjah celcius
ml	milililiter
µl	mikroliter
dl	desiliter
M	molar
mM	milimolar
nmol	nanomol
mmol	milimol
cm	sentimeter
mm	millimeter
µm	micrometer
kcal	kilokalori
pH	log kepekatan ion hydrogen
p	kebarangkalian
V	volt
mA	miliampere
n	bilangan subjek

BAB 1

PENDAHULUAN

1.1 PENGENALAN

Amalan gaya hidup sihat sangat penting dilakukan oleh setiap individu untuk mengekalkan kesihatan fizikal dan mental pada tahap terbaik. Kajian yang dilakukan oleh Jones et al. (2005) menunjukkan penduduk Asia lebih cenderung mendapat penyakit hati, penyakit akibat merokok, hipertensi, strok, diabetis dan kanser. Jadi, adalah perlu untuk memberikan kesedaran dan kempen pendidikan kepada orang awam selain menerapkan cara hidup sihat di dalam diri individu (Jones et al. 2005).

Senaman amat memberi manfaat kepada sistem imun tubuh. Walau bagaimanapun, manfaat yang diperolehi daripada senaman mungkin akan hilang apabila individu mengalami keletihan dan tidak dapat melakukan senaman secara berterusan (Tauler et al. 2006). Senaman yang berterusan pada peningkatan umur dapat membantu mengurangkan morbiditi dan mortaliti (Jonathan et al. 2004). Senaman biasa dan berintensiti sederhana dapat memberikan pelbagai kesan baik terhadap kesihatan termasuklah mengurangkan risiko penyakit kardiovaskular, kanser, osteoporosis dan kegemukan (Colin et al. 2002).

Penyakit kardiovaskular merupakan penyebab mortaliti dan morbiditi (Dubey et al. 2005). Penyakit ini perlu dicegah terutamanya di kalangan dewasa tua dengan melakukan senaman yang berterusan. Selain itu, senaman juga dapat menghalang dan merawat penyakit kronik yang lain (Houde & Melillo 2002). Selain daripada meningkatkan kapasiti kardiorespiratori (Galan et al. 2006), senaman yang berterusan dapat mengurangkan tekanan darah, kolesterol total dan LDL kolesterol. Ia juga

mampu meningkatkan HDL kolesterol dan memperbaiki fungsi endotelia (Leon & Sanchez 2001). Walau bagaimanapun, terdapat kajian yang menunjukkan bahawa senaman yang berintensiti tinggi apabila dilakukan secara berulang akan menyebabkan risiko penyakit kardiovaskular yang tinggi kepada ahli sukan (Smith 1995; Petibois & Deleris 2005; Santos-Silva 2001). Keadaan ini berlaku apabila terdapat tekanan oksidatif yang tinggi. Ozben & Kasapoglu (2001) mengatakan bahawa eritrosit lebih cenderung kepada kerosakan oksidatif sepanjang senaman kerana ia sangat terdedah kepada influks oksigen yang tinggi.

Walaupun senaman memberi banyak manfaat tetapi haruslah ditekankan bahawa bukan semua senaman sesuai dilakukan oleh golongan dewasa tua. Kajian lepas telah menunjukkan bahawa Tai Chi adalah senaman yang sangat sesuai disarankan kepada golongan dewasa tua kerana Tai Chi merupakan senaman yang berintensiti sederhana (Jancewicz 2001; Taylor-Piliae 2003). Ia merupakan senaman yang dipraktikkan oleh masyarakat Cina sejak berkurun dahulu dan dipercayai dapat memperbaiki ketahanan badan, meningkatkan fungsi koordinasi badan dan sebagainya (Jancewicz 2001). Ia sangat mudah serta boleh dilakukan bila-bila masa dan di mana sahaja tanpa memerlukan sebarang peralatan, mempunyai ritma yang tetap, dan tekanan fizikal serta mental yang rendah (Li et al. 2002). Apabila seseorang itu melakukan senaman Tai Chi dalam keadaan aman, tenang, menumpukan sepenuh perhatian dan pernafasan kepada setiap pergerakan, mereka akan merasai ketenangan fizikal dan psikologi (Jancewicz 2001). Tai Chi dapat memperbaiki keseimbangan tubuh badan kerana ia mengandungi pergerakan yang perlahan dan memerlukan koordinasi seluruh badan (Tsang et al. 2004). Ia juga dapat meningkatkan kestabilan postur dan mengelakkan risiko kejatuhan di kalangan golongan berumur (Taggart 2002). Daripada kajian-kajian lepas, dapatlah dilihat bahawa Tai Chi mampu mengurangkan risiko penyakit yang dialami semasa penuaan.

Salah satu punca penuaan adalah peningkatan radikal bebas apabila umur meningkat (Junqueira et al. 2004). Penglibatan radikal bebas dalam penuaan telah mula dibuktikan oleh Harman (1956) di mana beliau mencadangkan bahawa penuaan adalah proses yang disebabkan oleh kerosakan radikal bebas pada tisu dan sel badan (Peter 2002). Menurut Christopher & David (2003), tekanan oksidatif ialah gangguan

dalam keseimbangan pro-oksidan-antioksidan yang menyebabkan kerosakan lipid, protein dan DNA. Sepanjang melakukan senaman, terdapat pelbagai sumber yang berpotensi untuk menghasilkan spesies oksigen reaktif seperti anion superoksid, hidrogen peroksida dan radikal hidroksil (Christopher & David 2003).

Organisma mempunyai sistem untuk melindungi diri daripada penghasilan dan pemusnahan oleh ROS. Mekanisme detoksifikasi di dalam hati telah dikaji dan didapati bahawa enzim yang paling aktif adalah superoksida dismutase (SOD), katalase dan glutation peroksidase (GPx) (Ceconi et al. 2003). Kebanyakan kajian kesan Tai Chi yang dilakukan adalah lebih kepada kajian fizikal dan mental tetapi kurang kajian perubahan peringkat sel dengan menentukan parameter biokimia dijalankan. Oleh kerana senaman Tai Chi telah disarankan amat sesuai kepada dewasa tua dan kajian awal telah membuktikan bahawa Tai Chi berjaya menurunkan produk tekanan oksidatif (Noor Aini et al. 2004), kajian rentas ini dijalankan untuk melihat kesan senaman Tai Chi jangkamasa panjang ke atas profil kardiovaskular dan status oksidatif pada warga dewasa tua. Dalam kajian ini, kesan senaman Tai Chi ke atas aktiviti enzim antioksidan seperti superoksid dismutase (SOD), katalase (CAT) dan glutathione peroksidase (GPx), aras malondealdehid (MDA), produk AGE, kerosakan DNA dan aras vitamin antioksidan seperti vitamin A, C, dan E dianalisa pada individu yang melakukan senaman Tai Chi lebih daripada 2 tahun. Hasil kajian dapat memberi manfaat dalam mengurangkan penuaan dan menggalakkan cara hidup yang sihat pada semua individu.

1.2 OBJEKTIF PENYELIDIKAN

1.2.1 Objektif Umum

Kajian ini bertujuan untuk menentukan kesan senaman Tai Chi jangkamasa panjang (lebih daripada 2 tahun) ke atas profil kardiovaskular dan status oksidatif di kalangan dewasa tua.

1.2.2 Objektif Khusus

Objektif khusus kajian ini adalah untuk menentukan kesan senaman Tai Chi jangkamasa panjang ke atas:

- Profil kardiovaskular seperti kadar denyutan jantung dan tekanan darah.
- Profil lipid seperti aras LDL, HDL dan kolesterol.
- Status tekanan oksidatif seperti peroksidasi lipid dengan mengkaji aras MDA, glikosilasi dengan menentukan aras AGE serum, dan kerosakan DNA melalui pengasaian komet.
- Perlindungan enzim antioksidan seperti enzim superoksid dismutase (SOD), katalase (CAT) dan glutation peroksidase (GPx) serta vitamin antioksidan seperti vitamin A, C dan E.

1.3 HIPOTESIS KAJIAN

Hipotesis kajian yang dicadangkan adalah senaman Tai Chi jangkamasa panjang dijangka akan memberi perlindungan kardiovaskular dengan

- Merendahkan kadar denyutan jantung dan tekanan darah.
- Memperbaiki profil lipid dengan merendahkan LDL dan kolesterol serta meningkatkan HDL.
- Melindungi daripada tekanan oksidatif melalui penurunan peroksidasi lipid, aras AGE dan kerosakan DNA serta meningkatkan enzim antioksidan SOD, CAT, GPx dan vitamin antioksidan A, C dan E.

RUJUKAN

Acikgoz, O., Aksu, I., Topcu, A. & Kayatekin, B. M. 2006. Acute exhaustive exercise does not alter lipid peroxidation levels and antioxidant enzyme activities in rat hippocampus, prefrontal cortex and striatum. *Neuroscience Letters* 406: 148-151.

Aebi, H. 1984. Catalase in vitro. *Methods in Enzymology* 105:121-126.

Aguilo, A., Tauler, P., Fuentespina, E., Tur, A.J., Cordova, A. & Pons, A. 2005. Antioxidant response to oxidative stress induced by exhaustive exercise. *Physiology and Behavior* 84: 1-7.

Aguilo, A., Tauler, P., Guix, M.P., Illa, G., Cordova, A., Tur, J.A. & Pons, A. 2003. Effect of exercise intensity and training on antioxidants and cholesterol profile in cyclists. *Journal of Nutritional Biochemistry.* 14: 319-325.

Ahmed, R.G. 2005. The physiological and biochemical effects of diabetes on the balance between oxidative stress and antioxidant defense system. *Medical Journal of Islamic World Academy of Sciences* 15(1): 31-42.

Allen, R.G. & Tressini, M. 2000. Oxidative stress and gene regulation. *Free Radical & Biological Medicine* 28: 463-499.

Allessio, H.M. 1993. Exercise-induced oxidative stress. *Medical Science Sports Exercise.* 25: 218-224.

Allessio, H.M. & Goldfarb, A.H. 1988. Lipid peroxidation and scavenger enzymes during exercise: adaptive response to training. *Journal of Applied Physiology* 74: 965-969.

Alessio, H.M., Hagerman, A.E., Fulkerson, B.K., Ambrose, J., Rice, R.E. & Wiley, R.L. 2000. Generation of reactive oxygen species after exhaustive aerobic and isometric exercise. *Medical Science Sports Exercise* 32: 1576-1581.

Arumugam, T.V., Gleichmann, M., Tang, S.C., & Mattson, M. 2006. Hormesis/preconditioning mechanisms, the nervous system and aging. *Ageing Research Reviews* 5: 165-178.

Ashton, T., Young, I., Peters, J., Jones, E., Jackson, S., Davies,B., & Rowlands, C. 1999. Electron spin resonance spectroscopy, exercise, and oxidative stress: an ascorbic acid intervention study. *Journal of Applied Physiology* 87:2032–2036.

Aukrust, P., Luna, L., Ueland, T., Johansen, R.F., Muller, F., Froland, S.S., Seeberg, E.C., & Bjoras, M. 2005. Impaired base excision repair and accumulation of oxidative base lesions in CD4+ T cells of HIV-infected patients. *Blood* 105: 4730-4735.

Azzi, A., Boscobonik, D. & Hensey, C. 1992. The protein kinase C family. *Eur. Journal of Biochemistry* 208: 547.

Azzi, A., Boscoboinik, D., Ozer, N.K., Ricciarelli, R. & Aratri, E. 2000. Regulation and deregulation of vascular smooth muscle cells by reactive oxygen species and by α-tocopherol. Dlm. Hanninen, O. Packer, L. & Sen, C.K. (pnyt). *Handbook of Oxidants and Antioxidants in Exercise,* hlm. 403-430. Amsterdam: Elsevier.

Barnett, Y.A. & King, C.M. 1995. An investigation of antioxidant status, DNA repair capacity and mutation as a function of age in humans. *Mutation Res.* 338: 115-128.

Bates, C.J. 1995. Vitamin A. *Lancet.* 345: 31-35.

Baynes, J.W. 2001. The role of AGEs in aging: causation or correlation. *Experimental Gerontology* 36:1527-1537.

Bean, J.B., Vora, A. & Frontera, W.R. 2004. Benefits of exercise for community-dwelling older adults. *Archive Physics and Medical Rehabil* 85(3): S31-S42.

Bejma, J., Ramires, P. & Ji, L.L. 2000. Free radical generation and oxidative stress with aging and exercise: differential effects in the myocardium and liver. *Acta. Physiol. Scand.* 169: 343-351.

Bernabucci, U., Ronchi, B., Lacetera, N. & Nardone, A. 2002. Markers of oxidative status in plasma and erythrocytes of transition dairy cows during hot season. *Journal of Dairy Science* 85: 2173-2179.

Beyer, W.F. & Fridovich, I. 1987. Assaying for the superoxide dismutase activity: some large consequences of minor changes condition. *Analytical Biochemistry* 161: 559-266.

Burton, G.W. & Ingold, K.U. 1989. Vitamin E as an in vitro and in vivo antioxidant. *Annual NY Academic Sciences* 570: 7-22.

Blomhoff, R. 1994. Overview of vitamin A metabolism and function. Dlm. Blomhoff, R. (pnyt). *Vitamin A in health and disease*. Hlm 1-35. Marcel-Dekker, New York.

Braith, R.W & Stewart, K.J. 2006. Resistance Exercise Training: Its Role in the Prevention of Cardiovascular Disease. *Circulation* 113: 2642-2650.

Brites, F., Zago, V., Muzzio, M.L., Wilkinski, R. & Schreier, L. 2006. HDL capacity to inhibit LDL oxidation in well-trained triathletes. *Life Sciences* 78: 3074-3081.

Cadenas, E. & Davies, K.J.A. 2000. Mitochondrial free radical generation, oxidative stress and aging. *Free Radical & Biological Medicine* 29: 222-230.

Cadenas, E. & Sies, H. 1998. The lag phase. *Free Radical & Respiration* 28: 601-609.

Carmeli, E., Laviam, G. & Reznick, A.Z. 2000. The role of antioxidant nutrition in exercise and aging. Dlm. Radak, Z. (pnyt). *Free Radicals in Exercise and Aging,* hlm 73-115. Champaign: Human Kinetics.

Carr, A. & Frei, B. 1999. Does vitamin C act as a pro-oxidant under physiological conditions? *FASEB J.* 13: 1007-1024.

Cellabos-Picot, I., Trivier, J.M., Nicole, A., Sinet, P.M., Thevenin, M. 1992. Age-correlated modifications of copper-zinc superoxides dismutase and glutathione-related enzyme activities in human erythrocytes. *Clinical Chemistry* 38: 66-70.

Chaney, S.G. 2002. Principles of nutrition II: micronutrients. Dlm. Devlin, T.M. (pnyt.). *Textbook of Biochemistry with Clinical Correlations.* Ed. Ke-5, hlm. 1137-1168. New York: Wiley-Liss.

Chang, C.K., Huang, H.Y.M., Tseng, H.F. Hsuuo. Y.D. & Tso, T.K. 2007. Interaction of vitamin E and exercise training on oxidative stress and antioxidant enzyme activities in rat skeletal muscle. *Journal of Nutritional Biochemistry* 18: 39-45.

Channer, K.S. Barrow, D., Barrow, R., Osborne, M. & Ives, G. 1996. Changes in haemodynamic parameters following tai chi chuan and aerobic exercise in patients recovering from acute myocardial infarction. *Postgraduate Medical Journal* 72: 349-351.

Chen, K.M., Syder, M. & Krichbaum, K. 2001. Facilitators and barriers to elderd' practice of Tai Chi: a mind-body, low-intensity exercise. *Journal of Holisti & Nursing.* 19: 238-255.

Child, R.B., Wilkinson, D.M. & Fallowfield, J.L. 2000. Effect of a training taper on tissue damage indices, serum antioxidant capacity and half-marathon running performance. *International Journal of Sport Medicine* 21: 325-331

Christopher, M.D. & David, J.M. 2003. Exercise-associated oxidative stress. *Clinical Techniques in Equine Practice 2: 278-291.*

Colin, S., Jane, S.M., Andrew, R.C., Gavry, G.D., & John, R.S. 2002. Antioxidants enzyme activities, lipid peroxidation, and DNA oxidative damage: the effect

of short-term voluntary wheel running. *Archives of Biochemistry & Biophysics* 401: 255-261.

Cotman, C.W. & Berchtold, N.C. 2002. Exercise: a behavioural intervention to enhance brain health and plasticity. *Trends Neuroscience* 25: 295-301.

Cotman, C.W., Engesser-Cesar, C. 2002. Exercise enhances and protects brain function. *Exercise Sport Science Review* 30: 75-7

Couillard, C., Despres, J.P., Lamarche, B., Bergeron, J., Gagnon, J., Leon, A.S, Rao, D. C., Skinner, J.S., Wilmore, J.H. & Bouchard, C. 2001. Effects of endurance exercise training on plasma HDL cholesterol levels depend on level of triglycerides. *Arterioscler. Thromb. Vasc. Bio.* 21: 1226-1232.

Criswell, D., Powers, S., Dodd, S., Lawler, J., Edward, W., Renshler, K. & Grinton, S. 1993. High intensity training-induced changes in skeletal muscle antioxidant enzyme activity. *Medical Science & Sports Exercise* 25: 1135-1140.

Cuzzorcrea, S., Thiemermenn, C. & Saivemini, D. 2004. Potential therapeutic effect on antioxidant therapy in shock and inflammation. *Current. Medical Chemistry* 11: 1147-1162.

Das, D.K. & Maulik, N. 2000. Protection against free radical injury in the heart and cardiac performance. Dlm. Sen, C. K., Packer, L., & Hanninen, O (pnyt.). *Handbook of Oxidants and Antioxidants in Exercise*. Hlm 655-687. Amsterdam: Elsevier Science B.V.

Davies, K.J.A., Quintanilha, T.A., Parker, L. 1982. Free radical and tissue damage produced by exercise. *Biochem. Biophys. Res. Comm.* 107: 1198-1205.

Deaton, C.M. & Marlin, D.J. 2003. Exercise-associated oxidative stress. *Clinical Techniques in Equine Practice* 2: 278-291.

Decker, E.A. & Clarkson, P.M. 2000. Dietary sources and bioavailability of essential and nonessential antioxidants. Dlm. Sen, C.K., Packer, L. & Hanninen, O (pnyt.). *Handbook of Oxidants and Antioxidants in Exercise*. Hlm 323-358. Amsterdam: Elsevier Science B.V.

De Grey, A.D.N.J. 2002. H_2O: The forgotten radical. *DNA Cellular Biology* 21: 251-257.

Dubey, R.K., Imthurn, B., Barton, M. & Jackson, E.K. 2005. Vascular consequences of menopause and hormone therapy: importance of timing of treatment and type of estrogen. *Cardiovascular Research* 66; 295-302.

Dufaux, B., Heine, O., Kothe, A., Prinz, U. & Rost, R. 1997. Blood glutathione status following distance running. *Inernational Journal of Sports Medicine* 18: 89-93.

Dutchie. S.J., Ma, A., Ross, M.A., & Collins, A.R. 1996. Antioxidant supplementation decreases oxidative damage in human lymphocytes. *Cancer Respiratory* 56: 1291-1295.

Durstine, J., Grandjean, P. & Cox, C. 2002. Lipids, lipoproteins and exercise. *Journal of Cardiopulmunary Rehabilitation* 22: 385-397.

El-Yassin, H.D., Hasso, N.M.A. & Al-Rubayi, H.A. 2004. Lipid profile and lipid peroxidation pattern pre and post exercise in coronary artery disease. *Journal of Medical Sciences* 35: 223-228.

Fehrenbach, E., Passek, F., Niess, A. M., Pohla, H., Weinstock, C., Dickhuth, H.H. & Northoff, H. 2000. HSP expression in human leukocutes is modulated by endurance exercise. *Medical Science & Sports Exercise* 32: 592-600.

Franklin, B.A. 2000. Cardiovascular responses ti exercise and training. Dlm. Garrett, W.E & Kirkendall, D.T. (pnyt.). *Exercise and Sports Science,* hlm. 107-116. Philadelphia: Lippincott Williams & Wilkins.

Fridovich, I. Superoxide radicals, superoxides dismutases and the aerobic lifestyle. 1978. *Photobiol* 28: 733 – 741.

Fordyce, D.E., Wehner, J.M. 1993. Physical activity enhances spatial learning perfomance with an associated alteration in hippocampal protein kinase C activity in C57BL/6 and DBA/2 mice. *Brain Respiration* 619: 111-119.

Fry, J.M., Smith, G.M. & Speijers, E.J. 1993. Plasma and tissue concentrations of alpha-tocopherol during vitamin E depletion in sheep. *Journal of Nutrition.* 69: 225.

George, A.K. & Kristi, S.K. 2006. Aerobic exercise and lipids and lipoproteins in men: a meta-analysis of randomized controlled trials. *JMHG* 3: 61-70.

Glew, R. H. 2002. Lipid metabolism II: pathways of metabolism of special lipids. Dlm. Devlin, T. M. (pnyt). *Textbook of Biochemistry with Clinical Correlations.* D. ke-5, hlm. 727-777. New York: Wiley-Liss.

Gohil, K., Packer, L. & de Lumen, B. 1986. Vitamin E deficiency and vitamin C supplements: Exercise and mitochondrial oxidation. *Journal of Applied Physiology* 60: 1986-1991.

Gohil, K., Viguie, C., Stanley, W.C., Brooks, G.A. & Packer, L. 1988. Blood glutathione during human exercise. *Journal of Applied Physiology* 64: 115-119.

Goldfarb, A.H., McIntosh, M.K. & Boyer, B.T. 1994. Vitamin E effects on indexes of lipid peroxidation in muscle from DHEA-treated and exercised rats. *Journal of Applied Physiology* 76: 1630-1635.

Gomez-Cabrera, M.C., Domenech, E., Ji, L.L. & Vina, J. 2006. Exercise as an antioxidant: it up-regulates important enzymes for cells adaptations to exercise. *Science and Sports* 21: 85-89.

Griffiths, H.R., Moller, L., Bartosz, G., Hoberg, A.M., Loft, S., Lunec, J., Olinski, R., Parry, J., Pompella, A., Poulsen, H., Verhagen, H. & Astley, S.B. 2002. Biomarkers. *Molecular Aspects of. Medicine* 23: 101-208.

Halliwell, B. 1992. Reactive oxygen species and the central nervous system. *Journal of Neurochemistry* 59: 1609-1623.

Halliwell, B. & Gutteridge J.M.C. 1999. Oxidative stress: adaptation, damage, repair and death. *Free Radicals in Biology and Medicine. Oxford: Clarendon Press*

Han, D., Loukianoff, S., McLaughlin, L. 2000. Dlm. Sen, C. K., Packer, L., & Hanninen, O (pnyt.). *Handbook of Oxidants and Antioxidants in Exercise*. Hlm 323-358. Amsterdam: Elsevier Science B.V.

Harris, E. D. 1992. Regulation of antioxidant enzymes. *FASEB J.* 6:2675-2683.

Harman, D. J. 1956. Aging: a theory based on free radical and radiation chemistry. *Journal of Gerontology*. 11: 298-300.

Harman, D. 1981. The aging process. *Proc. Natl. Acad. Sci* 78: 7124-7128.

Hartmann, A. & Niess, A.M. 2000. Oxidative DNA damage in exercise. Dlm. Sen, C. K., Packer, L., & Hanninen, O (pnyt.). *Handbook of Oxidants and Antioxidants in Exercise*. Hlm 195-217. Amsterdam: Elsevier Science B.V.

Hartmann, A., Nieß, A.M., Grunert-Fuchs, M., Poch, B. & Speit, G. 1995. Vitamin E prevents exercise-induced DNA damage. *Mutation Resperation* 346: 195-202.

Hartmann, A., Pfuhler, S., Dennog, C., Germadnik, D., Pilger, A. & Speit, G. 1998. Exercise-induced DNA effects in human leucocytes are not accompanied by increased formation of 8-hydroxy-2'-deoxyguanosine or induction of micronuclei. *Free Radical in Biology & Medicine* 24(2): 245-251.

Hawley, J.A. & Zierath, J.R. 2004. Integration of metabolic and mitogenic signal transduction in skeletal muscle. *Exercise & Sport Science Review* 32: 4-8.

Hessel, E., Haberland, A., Muller, M., Lerche, D. & Schimke, I. 2000. Oxygen radical generation of neutrophils: a reason for oxidative stress during marathon running. *Clinica Chimica Acta* 298: 145-156.

Henderson, R.F., Bechtold, W.E., Bond, J.A. & Sun, J.D. 1989. The use of biological markers in toxicology. *Critical Review Toxicology* 20(2): 65-82.

Henry, C.L. 2004. Vitamin and mineral status: effects on physical performance. *Nutrition* 20: 632-644.

Higashi, Y. & Yoshizumi, M. 2004. Exercise and endothelial function: Role of endothelium-derived nitric oxide and oxidative stress in healthy subjects and hypertensive patients. *Pharmacology & Therapeutics* 102: 87-96.

Higuchi, M., Cartier, M.L.J. & Holloszy, J.O. 1985. Superoxides dismutase and catalase in skeletal muscle: adaptive respond to exercise. *Journal of Gerontology* 40: 281-286.

Hollander, J., Bejma, J., Ookawara, T., Ohno, H. & Ji, L.L. 2000. Superoxides dismutase gene expression in skeletal muscle: fiber-specific effect of age. *Mechanism of Ageing Development* 116: 345.

Hong, Y., Li, J.X. & Robinson, P.D. 2000. Balance control, flexibility and cardiorespiratory fitness among older Tai Chi practitioner. *Journal of Sports & Medical* 34: 29-34.

Hostmark, A.T. 2003. Serum albumin and prevalence of coronary heart disease: a population-based cross sectional study. *Norsk Epidemiology* 13(1):107-113.

Hwang, E.S. & Kim, G.H. 2007. Biomarkers for oxidative stress status of DNA, lipids, and proteins in vitro and in vivo cancer research. *Toxicology* 229: 1-10.

Inal, M.E., Kanbak, G. & Sunal, E. 2001. Antioxidant enzyme activities and malondialdehyde levels related to aging. *Clinica Chimica Acta* 305: 75-80

Jackson, M.J. 2000. Exercise and oxygen radical production by muscle. Dlm. Hanninen, O., Packer, L. & Sen, C.K. (pnyt.). *Handbook of Antioxidants and Antioxidants in Exercise*. hlm. 57-68. Amsterdam: Elsivier.

Jackson, M.J., Edwards, R.H. & Symons, M.C. 1985. Electron spin resonance studies of intact mammalian skeletal muscle. *Biochemica Biophysics Acta* 847: 185-190.

Jancewicz, A. 2001. Tai Chi Chuan's role in maintaining independence in ageing people with chronic disease. *Journal of Bodywork and Movement Therapies* 5: 70-77.

Jenkins, R.R. 1988. Free radical chemistry: Relationship to exercise. *Sport Medical* 5: 156-170.

Jonathan, F.B., Vora, A. & Frontera, W.R. 2004. Benefits of exercise for community-dwelling older adults. *Archives of Physical & Medical Rehabilitation* 85(3): 31-42.

Jones, A.Y., Dean, E. & Scudds, R.J. 2005. Effectiveness of a community-based tai chi program and implications for public health initiatives. *Archives of Physical & Medical Rehabilitation* 86: 619-625.

Ji, L.L. 1993. Antioxidant enzyme response to exercise and aging. *Medical Science & Sports Exercise* 25: 225-231.

Ji, L.L. 1995. Oxidative stress during exercise: Implication of antioxidant nutrients. *Free Radical Biology and Medicine* 18: 1079-1086.

Ji, L. L. 2000. Free radicals and antioxidants in exercise and sports. Dlm. Garett, W. E. & Kirkendall, D.T. (pnyt.). *Exercise & Sports Science,* hlm. 299-317. Philadelphia: Lippincott Williams & Wilkins.

Ji, L. L. 2001. Exercise at old age: does it increase or alleviate oxidative stress? *Annual. N. Y. Academical Sciences* 923: 236-247.

Ji, L. L. 2002. Exercise-induced modulation of antioxidant defense. *Annual N.Y. Academical Sciences* 959: 82-92.

Ji, L.L. 2007. Antioxidant signaling in skeletal muscle: A brief review. *Experimental Gerontology* 42: 582-593.

Ji, L.L., Dillon, D. & Wu, E. 1990. Alteration of antioxidant enzymes with aging in rat skeletal muscle. *Am. J.Physiol.* 256: 918-923.

Ji, L. L. & Fu, R.G. 1992. Responses of glutathione system and antioxidant enzymes to exhaustive exercise and hydroperoxide. *Journal of Applied Physiology* 64: 115-119.

Ji, L.L., Fu, R. G. & Mitchell, E. 1992. Glutathione and antioxidant enzyme in skeletal muscle: Effect of fiber type and exercise intensity. *Journal of Applied Physiology* 73: 1854-1859.

Ji, L.L, Stratman, F.W. & Lardy, H.A. 1998. Enzymatic down regulation with exercise in rat skeletal muscle. *Archves of Biochemistry & Biophysics* 263: 137-149.

Johnson, R.E., Mastropaolo, J.A. & Wharton, M.A. 1972. Exercise, dietary intake and body composition. *Journal of Am Diet* 60: 399.

Junqueira, V.B.C., Barros, S.B.M., Chan, S.S., Rodrigues, L., Giavarotti, L., Abud, R. L. & Deucher, G.P. 2004. Aging and oxidative stress. *Molecular Aspects of Medicine* 25: 5-16.

Kanter, M.M. 1994. Free radical, exercise and antioxidant supplementation. *International Journal of Sports & Nutritional* 4: 205.

Kanter, M.M., Nolte, L.A. & Holloszy, J.O. 1993. Effect of antioxidant vitamin mixture on lipid peroxidation at rest and postexercise. *Journal of Applied Physiology* 74: 965-969.

Kasparova, S., Brezova, V. Valko, M., Horecky, J., Mlynarik, V., Liptaj, T., Vancova, O., Ulicna, O. & Dobrota, D. 2005. Study of the oxidative stress in a rat model of chronic brain hypoperfusion. *Neurochemical International.* 46: 601-611.

Kasper, M. & Funk, R.H.W. 2001. Age-related changes in cells and tissues due to advanced glycation end products (AGEs). *Archives of Gerontology* 32: 233-243.

Kihlstrom, M.T. 1992. Lipid peroxidation capacities in the myocardium of endurance-trained rats and mice *in vitro. Acta Physiological Scandian* 146 : 177-183.

Kiran, T.R., Subramanyam, M.V.V. & Devi, S.A. 2004. Swim exercise training and adaptations in the antioxidant defense system of myocardium of old rats: relationship to swim intensity and duration. *Comparative Biochemistry & Physiology Part B.* 137: 187-196.

Kodama, S., Tanaka, S., Saito, K., Shu, M., Sone, Y. & Onitake, F. 2007. Effect of aerobic exercise on serum levels of higdensity lipoprotein cholesterol. *Archives of International Medicine* 167: 999-1007.

Kojda, G. & Hambrecht, R. 2005. Molecular mechanisms of vascular adaptations to exercise. Physical activity as an effective antioxidant therapy? *Cardiology & Respiratory:* 187-197.

Kojo, S. 2004. Vitamin C basic metabolism and its function as an index of oxidative stress. *Current Medical & Chemical* 11: 1041-1064.

Kowaltowski, A.J. & Verseci, A.E. 1999. Mitochondrial damage induced by conditions of oxidative stress. *Free Radical & Biological Medicine* 26: 463-471.

Kraus, W.E., Houmand, J.A., Duscha, B.D. & Whatton, M.C. 2002. Effects of the amount and intensity of exercise on plasma lipoprotein. *Journal of Medicine* 347:1483-1492.

Kurata, M., Suzuki, M. & Agar, N. S. 1993. Antioxidant systems and erythrocytes life-span in mammals. *Comparative Biochemistry Physiology- Part B* 106: 477-487.

Kweon, M.H., Park, Y., Sung, H.C. & Mukhtar, H. 2006. The novel antioxidant 3-O-caffeoyl-1-methylquinic acid induces Nrf2-dependent phase II detoxifying genes and alters intracellular glutathione redox. *Free Radical & Biological Medicine* 40: 1349-1361.

Lan, C., Lai, J. & Wong, M. 1996. Cardiorespiratory function, flexibility, and body composition among geriatric Tai Chi Chuan practitioners. *Archives of Physical and Medical Rehabilitation* 77: 612-616.

Lan, C., Lai, J.S. & Chen, S.Y. 1999. Tai Chi Chuan: an ancient wisdom on exercise and health promotion. *Sport Medicine* 32(4): 217-224.

Landis, G.N. & Tower, J. 2005. Superoxides dismutase evolution and life span regulation. *Mechanisms of Ageing and Development* 126: 365-379.

Lai, J.S., Lan, C., Wong, M.K. & Teng, S.H. 1995. Two-year trends in cardiorespiratory function among older tai chi Chuan practitioners and sedentary subjects. *American Gerontoly Society* 43: 1222-1227.

Lawler, J.M., Powers, S.K., Visser, T., Van Dijk, H., Kordus, M.J. & Ji, L.L. 1993. Acute exercise and skeletal muscle antioxidant and metabolic enzymes: effects of fiber type and age. *American Journal of Physiology* 96: 139-149.

Leon, A.S. & Sanchez, O. A. 2001. Response of blood lipids to exercise training alone or combined with dietary intervention. *Medicine & Sciences in Sports & Exercise* 33: S502-S515.

Leonard, S.S., Harris, G.K. & Shi, X.L. 2004. Metal-induced oxidative stress and signal transduction. *Free Radical & Biological Medicine* 37: 1921-1942.

Li, F., Fisher, K.J., Harmer, P. & Mc Auley, E. 2002. Delineating the impact of Tai Chi training on physical function among the elderly. *American Journal of Preventive Medicine* 23: 92-97.

Lin, C.Y., Chen, C.S., Shieh, M.S., Wu, C.H. & Lee, H.M. 2002. Development of an automated immunoassay for advanced glycosylation end products in human serum. *Clinical Biochemistry* 35: 189-195.

Liu, J., Yeo, H.C., Overvik-Douki, E., Hagen, T., Doniger, S.J. & Chu, D.W. 2000. Chronically and acutely exercised rats: biomarkers of oxidative stress and endogenous antioxidants. *Journal of Applied Physiology* 89: 21-28.

Long, Y., Widegren U. & Zierath, J.R. 2004. Exercise induced nitrogen activated protein kinase signaling in skeletal muscle. *Proc. Nutr. Soc.* 63: 227-232.

Lopez. M.E., Van Zeeland, N.L. Dahl, D.B., Weindruch, R. & Aiken, J.M. 2000. Celullar phenotypes of age-associated skeletal muscle mitochondrial abnormalities in rhesus monkeys. *Mutation & Respiration* 452: 123-138.

Machlin, L.J. 1991. Handbook of vitamins. Ed ke-2. New York: Marcel Dekker.

Machlin, L.J. & Bendich, A. 1987. Free radical tissue damage. Protective role of antioxidant nutrients. *FASEB J.* 1:441.

Manfredi, T., Fielding, R., O'Reilly, K., Meredith, C., Lee, H. & Evans, W. 1991. Plasma creatine kinase activity and exercise-induced muscle damage in older men. *Medical Science & Sports Exercise* 23: 1028–1034.

Marzatico, F., Pansarasa, O., Bertorelli, L., Somenzini, L. & Della Valle, G. 1997. Blood free radical antioxidant enzymes and lipid peroxides following long-distance and lactacidemic performances in highly trained aerobic and sprint athletes. *Journal of Sports Meicine & Physical Fitness* 37: 235-239.

Mastaloudis, A., Leonard, S. & Traber, M. 2001. Oxidative stress in athletes during extreme endurance training. *Free Radical & BiologicalMedicine* 31:911–922.

Maugeri, D., Santangelo, A., Bonanno, M. R., Testai, M., Abbate, S., Logiudice, F., Mamazza, C., Puglisi, N. & Panebianco, P. 2004. Oxidative stress and aging: Studies on an east-sicilian ultraoctagenarian population living in institutes or at home. *Archives of Gerontology & Geriatric Supply* 9: 271-277.

Maughan, R.J., Donelly, A.R., Gleeson, M., Whiting, P.H. & Walker, K.A. 1989. Delayed onset muscle damage and lipid peroxidation in man after a downhill run. *Muscle Nerve* 12: 332-336.

McArdle, A., Katch, F. I. & Katch, V.L. 1994. Training the anaerobic and aerobic energy systems. Dlm. Harris, J.M. (pnyt.). *Essentials of Exercise Physiology,* hlm. 342-369. Philadelphia:Lea&Febiger.

Mcbride, J., Kraemer, W., Triplett-Mcbride, T. & Sebastianelli, W.1998. Effect of resistance exercise on free radical production. *Medical Science & Sports Exercise* 30: 67–72.

McCall, M.Rr. & Frei, B. 1999. Can antioxidant vitamins materially reduce oxidative damage in humans *Free Radical Biological & Medicine* 26: 1034-1053.

McCarter, R.J.M. 2000. Caloric restriction, exercise and aging. Dlm. Hanninen, O., Packer, L. & Sen, C.K. (pnyt.). *Handbook of Oxidants and Antioxidants in Exercise,* hlm. 797-829. Amsterdam: Elsevier.

Meletis, C.D. 2003. Chloride: the forgotten essential mineral. http.www.eletewater.com [5 Januari 2009].

Meydani, M. & Evans, W.J. 1993. Free radicals, exercise, and aging. Dlm. Yu, B.P. (pnyt). *Free Radicals In Aging,* hlm. 183-204. Boca Raton: CRC Press.

Meydani, M., Evans, W.J., Handelman, G., Biddle, L., Fielding,R.A., Meydani, S.N., Burill, J., Fiatarone, M.A., Blumberg, J.B. & Cannon, J.G. 1993. Protective effect of vitamin E on exercise induced oxidative damage in young and older adults. *American Journal of Physiology* 264:R992–R998.

Miquel, J. 1989. Historical introduction to free radical and antioxidant biomedical research. Dlm. Miquel, J., Quintanilha, A.T. & Weber, H. *Handbook of free radicals and antioxidants in biomedicine.* Hlm. 3-13. Boca Raton: CRC Press.

Mishima, K., Tanaka, T., Pu, F., Egashira, N., Iwasaki, K. & Hidaka, R. 2003. Vitamin E isoforms α-tocotrienol and γ-tocopherol prevent cerebral infarction in mice. *Neuroscience Letter* 337: 56-60.

Miyazaki, H., Oh-Ishi, S., Ookawara, T., Kizaki, T., Toshinai, K., Ha, S., Haga, S., Ji, L. L. & Ohno, H: 2001. Strenuous endurance training in humans reduces oxidative stress following exhausting exercise. *Eur. Journal of Appllied Physiology* 84 : 1-6.

Moller, P., Wallin, H. & Knudsen, L.E. 1996. Oxidative stress associated with exercise, psychological stress and life-style factors. *Chemical & Biological Interactions.* 102: 17-36.

Molteni, R., Zheng, J.Q., Ying, Z., Gomez-Pinilla, F., Twiss, J.L. 2004. Voluntary exercise increases axonal regeneration from sensory neurons. *Proc. Natl. Acad. Sci.* 101: 8473-8478.

Morimura, K., Romanenko, A., Min, W., Salim, E.I., Kinoshita, A., Wanibuchi, H., Vozianov, A. & Fukushima, S. 2004. Possible distinct molecular carcinogenic pathways for bladder cancer in Ukraine, before and after the Chernobyl disaster. *Oncology Repiratory* 11: 881-886.

Muradian, K.K., Utho, N. A., Fraifeld, V., Mozzhukhina, T.G., Dishel, I. N. & Litoshenko, A. Y. 2002. Superoxides dismutase, catalase and glutathione peroxidase activities in the liver of young and old mice: linear regression and correlation. *Archives of Gerontology and Geriatrics* 35: 205-214.

Nakabeppu, Y., Tsuchimoto, D., Ichinoe, A., Ohno, M., Ide, Y., Hirano, S., Yoshimura, D., Tominaga, Y., Furuichi, M. & Sakumi, K. 2004. Biological significance of the defense mechanisms against oxidative damage in nucleic acids caused by reactive oxygen spesies. *Ann. N. Y. Acad. Sci.* 1011: 101-111.

Navarro-Arevalo, A. & Sanchez-del-Pino, M.J. 1998. Age and exercise-related changes in lipid peroxidation and superoxide dismutase activity in liver and soleus muscle tissues of rats. *Mechanisms of Ageing and Development* 104: 91-102.

Nazaimoon, W.M & Khalid, B.A.K. 1998. Enzyme immunoassay for advanced glycosylation end-product in serum. *Malaysian Journal Of Phatology* 20(2) : 1-7.

Neeper, S.A., Gomez-Pinilla, F., Choi, J. & Cotman, C.W. 1996. Physical activity increase mRNA for brain-derived neurotrophic factor and nerve growth factor in rat brain. *Brain Respiration* 126: 49-56.

Niess, A. M., Hartmann, A., Fuchs-Grunert, M., Poch, B. & Speit, G. 1996. DNA damage after exhaustive treadmill running in trained and untrained men. *International Journal of Sports Medicine* 17: 397-403.

Niess, A., Sommer, M., Schneider, M., Angres, C., Tschositsch,K., Golly, I., Battenfeld, N., Northoff, H., Biesalski, H., Dickhuth,H. & Fehrenbach, E. 2000. Physical exercise-induced expression of inducible nitric oxide synthase and heme oxygenase-1 in human leukocytes: effects of RRR-alpha-tocopherol

supplementation. *Antioxidants & Redox Signal*. 2: 113–126.

Nohl, H. 1993. Involvement of free radicals in ageing: a consequence or cause of senescence. *Free Radical & Medicine* 49: 653-667.

Nohynek, G.J., Meuling, W.J.A., Vaes, W.H. J., Lawrence, R.S., Shapiro, S., Schulte, S., Steiling, W., Bausch, J., Gerber, E., Sasa, H. & Nau, H. 2006. Repeated tropical trestment, in contrast to single oral doses, with vitamin A-containing preparations does not affect plasma concentrations of retinol, retinyl esters or retinoic acids in female subjects of child-bearing age. *Toxicology Letters* 163: 65-76.

Oh-Ishi, S., Kizaki, T., Yamashita, H., Nagata, N., Suzuki, K., Taniguchi, N. & Ohna, H. 1996. Alteration of superoxides dismutase iso-enzyme activity, content and mRNA expression with aging in rat skeletal muscle. *Mecanism of. Aging Development* 84: 65-76.

Oh-Ishi, S., Kizaki, T., Okawara, T., Sakurai, T., Izawa, T. & Nagata, N. 1997. Age and exercise-related changes in lipid peroxidation and superoxides dismutase in liver and soleus muscle tissue rats. *Mechanism of Aging Development* 104: 91- 102.

Oh-Ishi, S., Kizaki, T., Okawara, T., Sakurai, T., Izawa, T. & Nagata, N. 1997. Endurance training improves the resistance of rat diaphragm to exercise-induced oxidative stress. *American Journal of Respiratory & Critical Care Medicine* 156: 1579-1585.

Ohno, H., Suzuki, K., Ffujii, J., Yamashita, H., Kizaki, T., Oh-Ishi, S. & Taniguchi, N. 1994. Exercise and Oxygen Toxicity. Amsterdam: Elsevier Publisher.

Oliveros, L., Vega, V., Anzulovich, A.C., Ramirez, D. & Gimenez, M.S. 2000. Vitamin A defiency modifies antioxidant defences and essential elememt contents in rat heart. *Nutrition Research* 20(8): 1139-1150.

Orhan, H., Gurer-Orhan, H., Vriese, E., Vermeulen, N.P.E. & Meerman, J.H.N. 2006. Application of lipid peroxidation and protein oxidation biomarkers for oxidative damage in mammalian cells. A comparison with two fluorescent probes. *Toxicology in Vitro* 20: 1005-1013.

Ozben. T & Kasapoglu, M. 2001. alteration of antioxidant enzymes and oxidative stress markers in aging. *Experimental Gerontology* 36: 209-220.

Pachla, L. A. & Kissinger. 1979. Analysis of ascorbic acids by liquid chromatography with amperometric detection. *Methods Enzymology* 62: 15-24.

Packer, L., Almada, A.L. & Rothfuss, L.M. 1989. Modulation of tissue vitamin E levels by physical exercise. *Ann. New York Acad. Sci.* 570: 311-321.

Packer, L., Reznick, A., Simon-Schnass, I. & Landvik, S. 1993. Significance of

vitamin E for the athlete. Dlm. Packer, L. & Fuchs, J. (pnyt) *Vitamin E in health and disease*. Hlm 465-472. New York: Marcel Dekker.

Paglia, D.E. & Valentine, W. N. 1967. Studies of quantitative and qualitative characterization of erythrocyte glutathione peroxidase. *Clinical Medicine* 70(1): 158-169.

Palace, V.P., Khaper, N., Qin, Q. & Singal, P.K. 1999. Antioxidant potential of vitamin A and caroteinoids and their relevance to heart disease. *Free Radical & Biological Medicine* 26: 746-761.

Paraskevas, G.P., Kapaki, E., Petropoulou, O., Anagnostouli, M., Vagenas, V. & Papageorgiou, C. 2003. Plasma levels of antioxidant vitamin C and E are decreased in vascular parkinsonism. *Journal of the Neurological Science* 215: 51-55.

Parise, G., Brose, A.N. & Tarnopolsky, M.A. 2005. Resistance exercise training decreases oxidative damage to DNA and increase cytochrome oxidase activity in older adults. *Experimental Gerontology* 40: 173-180.

Pedersen B.K & Saltin B. 2006. Evidence for prescribing exercise as therapy in chronic disease. *Scand. Journal of Medical Sciences & Sports* 1: 3 –63.

Petibois, C. & Deleris, G. 2005. Erythrocyte adaptation to oxidative stress in endurance training. *Archives of Medical Research* 36: 524-531.

Pette, D & Spamer, C. 1986. Metabolic properties of muscle fibers. *Fed. Proc.* 45:2910.

Pereira, B., Costa Rosa, L.F.B., Safi, D.A., Medeiros, M.H.G., Curi, R. & Bechara, E.J.H. 1994. Superoxide dismutase, catalase, and glutathione peoxidase activities in muscle and lymphoid organs of sedentary and exercise-trained rats. *Physiological Behaviour* 98:1095-1099.

Pigeolet, E., Corbisier, P., Houbion, A., Lambert, D., Michiels, C., Raes, M., Zachary, M. D. & Remacle, J. 1990. Glutathione peroxidase, superoxides dismutase, and catalase inactivation by peroxides and oxygen derived free radicals. *Mechanism of Ageing and Development* 51: 283-297.

Pigeolet, E. & Remacle, J. 1991. Susceptibility of glutathione peroxidase to proteolisis after oxidative alteration by peroxides and hydroxyl radicals. *Free Radical & Biological Medicine* 11: 191-195.

Pinho, R.A., Andrades, M.E., Oliveira, M.R., Pirola, A.C., Zago, M.S., Silveira, P.C. L., Dal-Pizzol, F. & Moreira, J.C.F. 2006. Imbalance in SOD/CAT activities in rat skeletal muscles submitted to treadmill training exercise. *Cell Biology International* 30: 848-853.

Pool-Zobel, B.L., Bub, A., Muller, H., Wollowski, I. & Rechkemmer, G. 1997.

Consumption of vegetables reduces genetic damage in human: first results of a human intervention trial with carotenoid-rich foods. *Carcinogenesis* 18: 1847-1850.

Powers, S.K., Criswell, D., Lawler, J., Martin, D., Lieu, F.K. & Ji, L.L. 1993. Rigorous exercise training increases superoxides dismutase activity in the ventricular myocardium. *American Physiology* 265: H2094-H2098.

Powers, S.K., Criswell, D., Lawler, L., Ji, L.L., Martin, D. & Herb, R.A. 1994. Influence of exercise and fiber type on antioxidant enzyme activity in rat skeletal muscle. *American Journal of Physiology* 266: 375-380.

Powers, S.K. & Sen, C.K. 2000. Physiological antioxidants and exercise training. Dlm. Sen, C.K., Packer, L. & Hanninen, O. (pnyt). *Handbook of Oxidants and Antioxidants in Exercise,* hlm. 221-242, Amsterdam: Elsevier Science B.V.

Prabhu, H.R. 2002. In vivo inhibition of selenium dependent glutathione peroxidase and superoxides dismutase in rats by diethyldithiocarbamate. *Indian Journal of Experimental Biology* 40: 258-261.

Radak, Z., Apor, P., Pucsok, J., Berkes, I., Ogonovszky, H., Pavlik, G., Nakamoto, H. & Goto, S. 2003. Marathon running alters the DNA base excision repair in human skeletal muscle. *Life Science* 72: 1627-1633.

Radak, Z., Kaneko, T., Tahara, S., Nakamoto, H., Ohno, H. & Sasvari, M. 1999. The effect of exercise training on oxidative damage of lipids, proteins, and DNA in rat skeletal muscle: evidence for beneficial outcomes. *Free Radical & Biological Medicine* 27: 69-74.

Radak, Z., Naito, H., Kaneko, T., Tahara, S., Nakamoto, H., Takahashi, R., Cardozo-Pelaez, F. & Goto, S. 2002. Exercise training decreases DNA damage and increases DNA repair and resistance against oxidative stress of proteins in aged rat skeletal muscle. *Pflugers Archives* 445: 273-278.

Ramasamy, R., Vannucci, S.J., Yan, S.S.D., Herold, K., Yan, S.F. & Schmidt, A.M. 2005. Advanced glycation end products and RAGE: a common thread in aging, diabetes, neurodegeneration, and inflammation. *Glycobiology* 15(7): 16R–28R.

Rand, M.L., Harfenist, E.J. & Murray, R.K. 1996. Plasma proteins, immunoglobulins, & blood coagulation. Dlm. Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (pnyt.). *Harper's Biochemistry.* Ed. Ke-24, hlm. 707-732. Connecticut: Appleton & Lange.

Reid, M.B., Shoji, T., Moody, M.R. & Entman, M.L. 1992. Reactive oxygen in skeletal. II. Extracellular release of free radicals. *Journal of Applied Physiology* 73: 1805-1809.

Reznick, A.Z., Witt, E.H., Silbermann, M. & Packer, L. 1992. The threshold of age in

exercise and antioxidants action. Dlm. Emeritt, I. & Chance, B. (pnyt). *Free Radicals and Aging,* hlm. 423-427. Basel: Birkhauser Verlag.

Retsky, K.L., Chen, K., Zeind, J. & Frei, B. 1999. Inhibition of copper- induced LDL oxidation by vitamin C is associated with decreased copper binding to LDL and @-oxo-histidine formation. *Free Radical & Biological Medicine* 26: 90-98.

Rokitzki, L., Logemann, E., Sagredos, A., Murphy, M., Wetzel-Roth, W. & Keul, J. 1994. Lipid peroxidation and antioxidative vitamins under extreme endurance stress. *Acta Physiological Scandium* 151: 149–158.

Rowland, T.W. 2005. Circulatory responses to exercise : are we misreading? Chest 127: 1023-1030.

Rousseau, A.S., Margaritis, I., Arnaud, J., Faure, H. & Roussel, A.M. 2006. Physical activity alters antioxidant status in exercising elderly subjects. *Journal of Nutritional Biochemistry* 17: 463-470.

Sahlin, K., Ekberg, K. & Cizinsky, S. 1991. Changes in plasma hypoxanthine and free radicals markers during exercise in man. *Acta Physiological Scand.* 142: 273-281.

Sakata, N., Uesugia, N., Takebayashia, S., Nagaib, R., Jonob, T., Horiuchi, S., Takeya, M., Itabe, H., Takano, T. & Myint, T. 2001. Glycoxidation and lipid peroxidation of low-density lipoprotein can synergistically enhance atherogenesis. *Cardiovascular Research* 49: 466–475.

Sandlund, E.S. & Norlander, T. 2000. The effects of Tai chi chuan relaxation and exercise on stress responses and ell-being: an overview research. *International Journal of Stress Management.* 7(2): 139-149.

Santos-Silva, A., Rebelo, M. I., Castro, E.M., Guerra, A., Rego, C. & Quintanilha, A. 2001. Leukocyte activation, erythrocyte damage, lipid profile and oxidative stress imposed by high competition physical exercise in adolescents. *Clinica Chimica Acta.* 306: 119-126.

Selamoglu, S., Turgay, F. & Kayatekin, B.M. 2000. Aerobic and anaerobic training effect on the antioxidant enzymes of the blood. *Acta Physiological Hung.* 87: 267-273.

Selman, C., McLaren, J.S., Collins, A.R., Duthie, G.G. & Speakman, J.R. 2002. Antioxidant enzyme activities, lipid peroxidation, and DNA oxidative damage: the effects of short-term voluntary wheel running. *Archives of Biochemistry and Biophysics* 401: 255-261.

Semin, I., Kayatekin, B.M., Gonenc, S., Acikgoz, O., Uysal, N. & Gure, A. 2000.

Lipid peroxidation and antioxidant enzyme level of intestinal renal and muscle tissue after a 60 min exercise in trained mice. *Indian Journal of Physiology & Pharmacology* 44: 419-427.

Sen, C.K., Khanna, S., Roy, S. & Packer, L. 2000. Molecular basis of vitamin E: tocotrienol potently inhibits glutamate-induced pp60c-Src kinase activation and death of HT4 neuronal cells. *Journal of Biology & Chemistry* 275(17): 13049-13055.

Sharp, R.L. 2006. Role of sodium homeostasis with exercise. *Journal of The American College Of Nutrition.* 25: 231S-239S.

Sharpe, D.C., Mulholland, C. & Trinick, T. 1996. Ascorbate and malondialdehyde in stroke patients. *Ir. Journal of Medical Sciences* 163: 488-497.

Shinde, V., Dhalwal, K., & Mahadik, K.R. 2007. Ageing and its different perspectives. *Pharmacognosy Reviews* 1(2): 265-269.

Sies, H. 1993. Strategies of antioxidant defense. *Eur. Journal of Biochemistry* 215: 213-219.

Sim, A.S., Salonikas, C., Naidoo, D. & Wilcken, D.E.L. 2003. Improved method for plasma malondialdehyde measurement by high performance liquid chromatography using methyl malondialdehyde as an internal standard. *Journal of Chromatography B* 785: 337-344.

Simmons, R.A., Suponitsky-Kroyter, I. & Selak, M.A. 2005. Progressive accumulation of mitochondrial DNA mutations and decline in mitochondrial function lead to beta cell failure. *Journal of Biology & Chemistry* 280: 28785-28791.

Simonoff, M., Sergeant, C., Garnier, N., Moretto, P., Llabador, Y., Simonoff, G. & Conri, C. 1992. Antioxidant statua)selenium, vitamin A and E) and aging. Dlm. Emeritt, I. & Chance, B. (pnyt.). *Free Radicals and Aging,* hlm. 419-422. Basel: Birkhauser Verlag.

Sjodin, B., Westing, H. & Apple, S. 1990. Biochemical mechanisms for oxygen free radical formation during exercise. *Sports Medicine* 10: 236-254.

Smith, J.A. 1995. Exercise, training and red blood cells turnover. *Sports Medicine* 19: 9-31.

Souza-Pinto, N.C., Hogue, B.A. & Bohr, V.A. 2001. DNA repair and aging in mouse liver: -oxo-DG, glycosylate activiti increases in mitochondrial but not in nuclear extracts. *Free Radical & Biological Medicine* 30(8): 916-923.

Stocker, R. & Keaney, J.F. 2004. Role of Oxidative Modifications in Atherosclerosis. *Physiology Review.* 84: 1381–1478.

Sumida, S.K. Tanaka, H. & Kiato, F. 1989. Exercise-induced lipid peroxidation and leakage of enzymes before and after vitamin E supplementation. *International Journal of Biochemistry* 21 : 835-838.

Taggart, H.M. 2002. Effects of Tai Chi on balance, functional mobility and fear of falling among older women. *Applied Nursing* 15(4): 235-242.

Tauler, P., Sureda, A., Cases, N., Aguilo, A., Rodrigues-Marroyo, J.A., Villa, G., Tur, J.A. & Pons, A. 2006. Increased lymphocyte antioxidant defences in response to exhaustive exercise do not prevent oxidative damage. *Journal of Nutritional Biochemistry* 17: 665-671.

Tee, E.S. & Khor, S.C. 1999. Simultaneous determination of retinol and α-tocopherol by high pressure liquid chromatography in micro-volume of serum. *Malaysia Journal of Nutrition.* 5: 21-30.

Terblanche, S.E. 2000. The effect of exhaustive exercise on the activity levels of catalase in various tissue of male and female rats. *Cellular & Biological International* 23: 749- 753.

Terman, A. & Brunk, U.T. 2004. Aging as a catabolic malfunction. *The International Journal of Biochemistry & Cell Biology* 36: 2365-2375.

Thompson, P., Crouse, S. & Goodpaster, B. 2001. The acute versus the chronic response to exercise. *Medical Science & Sports Exercise* 33: S438-S445.

Tiidus, P.M., Pushkarenko, J. & Houston, M.E. 1996. Lack of antioxidant adaptation to short-term aerobic training in human muscle. *American Journal & Physiology* 271: R832-R836.

Tirosh, O. & Reznick, A.Z. 2000. Chemical bases and biological relevance of protein oxidation. Dlm. Sen, C. K., Packer, L., & Hanninen, O (pnyt.). *Handbook of Oxidants and Antioxidants in Exercise*. Hlm 89-114. Amsterdam: Elsevier Science B.V.

Tsai, A.C., Sandretto, A. & Chung, Y.C. 2003. Dieting is more effecting in reducing weight but exercise is more effective in reducing fat during the early phase of a weight-reducing program in healthy human. *The Journal of Nutritional Biochemistry* 14 : 541-549.

Tsang, W.W., Wong, V.S., Fu, S.N. & Hui-Chan, C.W. 2004. Tai chi improves standing balance control under reduced or conflicting sensory conditions. *Archives of Physical & Medical Rehabilitation.* 85: 129-137.

Tse, S.K. & Baily, D.M. 1992. Tai Chi and postural control in the well elderly. *American Journal of Occupational Theory.* 46: 295-300.

Urso, M.L. & Clarson, P.M. 2003. Oxidative stress, exercise and antioxidant supplementation. *Toxicology* 189: 41-54.

Umegaki, K., Daohua, P., Sugisawa, A., Kimura, M. & Higuchi, M. 2000. Influence of one bout of vigorous exercise on ascorbic acid in plasma and oxidative damage to DNA in blood cells and muscle in untrained rats. *Journal of Nutritional Biochemistry* 11:401-407.

Valko, M., Izakovic, M., Mazur, M., Rhodes, C.J. & Telser, J. 2004. Role of oxygen radicals in DNA damage and cancer incidence. *Molecular & Cellular Biochemistry* 266: 37-56.

Valko, M., Morris, H. & Cronin, M.T.D. 2005. Cronin, metals, toxicity and oxidative stress. *Curr. Med. Chem.* 12: 1161-1208.

Valko,M., Morris, H., Mazur, M., Rapta, D. & Bilton, R.F. 2001. Oxygen free radical generating mechanisms in the colon: do the semiquinones of vitamin K play a role in the aetiology of colon cancer? *Biochemica Biophysical Acta* 1527: 161-166.

Valko, M., Rhodes, C.J., Moncol, J., Izakovic, M. & Mazur, M. 2006. Free radicals, metals and antioxidants in oxidative stress-induced cancer. *Chemico-Biological Interactions* 160: 1-40.

Valls, V., Peiro, P., Muniz, P. & Saez, G. T. 2005. Age-related changes in antioxidant status and oxidative damage to lipids and dna in mitochondria of rat liver. *Process Biochemistry* 40: 903-908.

Van Praag, H., Kempermann, G. & Gage, F.H. 1999. Running increase cell proliferation and neurogenesis in the adult mouse dentate gyrus. *Nat. Neuroscience* 2: 266-270.

Vina, J., Borras, C., Gomez-Cabrera, M.C. & Orr, W.C. 2006. Importance of reactive oxygen species to modulate molecular and cellular response to stress. *Free Radical & Respiration* 40(2): 111-119.

Vincent, K.R., Braith, R.W., Feldman, R.A., Kallas, H.E. & Lowenthal, D.T. 2002. Improved cardiorespiratory endurance following 6 months of resistance exercisein elderly men and women. *Archives of International Medicine* 162:673-678.

Weaver, C.M. 2000. Calcium requirements of physically active people. *American Journal of Clinical & Nutritional.* 72: 579S-584S.

Witt, E. H., Reznick, A. Z., Viguie, C. A., Starke-Reed, P. & Packer, L. 1992. Exercise, oxidative damage and effects of antioxidant metabolism. *Journal of Nutrition* 122: 766-773.

Wolf, S.L., O'Grady, M., Easley, K.A., Guo, Y., Kressig, R.W. & Kutner, M. 2006. The influence of intense Tai Chi training on physical performance and hemodynamic outcomes in transitionally frail, older adults. *The Journal of*

Gerontology 61: 184-189.

Wolfson, L., Whipple, R. Derby, C., Judge, J., King, M., Amerman, P., Schmidt, J. & Smyers, D. 1996. Balance and strength training in older adults: intervention gains and Tai Chi maintenance. *Journal of American Gerontology Society* 44: 498-506.

Yoshida, Y., Niki, E. & Noguchi, N. 2003. Comparative study on the action of tocopherol and tocotrienols as antioxidants: chemical and physical effects. *Chemistry & Physical. Lipids* 123: 63-75.

You, W.C., Zhang, L., Gaii, M.H., Chang, Y.S., Liu, W.D., Ma, J.L., Li, J.Y., Jin, M. L., Hu, Y.F., Yang, C.S., Blaser, M.J., Correa, P., Blot, W.J., Fraumeni, J.F. & Xu, G.W. 2000. Gastric cancer: *Helicobacter pylori,* serum vitamin C, and other risk factors. *J. Natl. Cancer Inst.* 92:1607-1612.

Young, I.S. & Woodside, J.V. 2001. Antioxidants in health and disease. *Journal of Clinical. Pathology* 54: 176-186.