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The Effects of High Intensity Progressive Resistance Training on Psychological Stress and Biochemicals Parameters

(Kesan Senaman Rintangan Intensiti Tinggi Berprogregresif ke Atas Stres Psikologi dan Parameter Biokimia)

ARIMI FITRI MAT LUDIN, LAU HUI JIN, SUHANIZA SAIRAN, MAHADIR AHMAD & NOR FARAH MOHD FAUZI

ABSTRACT

Stress is a common problem among university students and studies showed that involvement in exercise could help in reducing stress. However, information regarding the effect of high intensity progressive resistance training (PRT) using a resistant tube on stress among inactive and moderate active young male university students is limited. Hence, the aim of this study is to examine the effect of high intensity PRT using a resistant tube on psychological stress level, cortisol, DHEA and physical fitness in this population. A total of 30 male university students were participated in this quasi-experiment study. Intervention group (n = 14, age: 21.50 ± 1.37 yr) was participaned to carry out high intensity PRT by using resistant tube 3 times per week for 10 weeks; control group (n = 16, age: 21.29 ± 1.86 yr) was asked to continue their current lifestyle as usual. Before and after 10 weeks of intervention, psychological stress was measured by using PSS and SLSI questionnaires; cortisol and DHEA level were measured by using ELISA method. Timed up-and-go (TUG) used to examine dynamic balance and handgrip strength test used to measure muscle strength. Findings showed that the increased of DHEA level after 10 weeks of intervention was significantly difference between control and intervention groups ($p < 0.05$). There was no significant group difference in changes over time in anthropometric and body composition measurements, stress scores, cortisol level and physical fitness. High intensity PRT using resistant tube may be beneficial in increasing DHEA level among young male adults, which can act as a stress biochemical indicator.

Keywords: Progressive resistance training; psychological stress; cortisol; DHEA; physical fitness

ABSTRAK

Tekanan merupakan satu masalah yang sering dihadapi oleh pelajar universiti dan kajian menunjukkan penglibatan dalam senaman dapat membantu dalam menurunkan tekanan. Namun begitu, maklumat mengenai kesan senaman rintangan progresif (PRT) intensiti tinggi dengan menggunakan tiub rintangan ke atas tekanan di kalangan pelajar lelaki muda yang tidak aktif dan sederhana aktif adalah terhad. Justeru, tujuan kajian ini adalah untuk mengkaji keberkesanan PRT intensiti tinggi dengan menggunakan tiub rintangan ke atas tahap tekanan psikologi, kortisol, DHEA dan kecergasan fizikal dalam populasi ini. Seramai 30 pelajar lelaki universiti mengambil bahagian dalam kajian eksperimen kuasi ini. Kumpulan intervensi (n = 14, umur: 21.50 ± 1.37) mengikuti PRT intensiti tinggi dengan menggunakan tiub rintangan 3 kali seminggu selama 10 minggu; kumpulan kawalan (n = 16, umur: 21.29 ± 1.86) diminta meneruskan gaya hidup mereka seperti biasa. Sebelum and selepas 10 minggu intervensi, stres psikologi dinilai dengan borang soal selidik PSS dan SLSI, aras kortisol dan DHEA diukur dengan kaedah ELISA. Ujian timed up-and-go (TUG) digunakan untuk menilai keseimbangan dinamik dan ujian genggaman tangan digunakan untuk mengukur kekuatan otot. Keputusan menunjukkan peningkatan aras DHEA selepas 10 minggu intervensi adalah berbeza secara signifikan di antara kumpulan kawalan dan intervensi ($p < 0.05$). Tiada perbezaan kumpulan yang signifikan sepanjang masa intervensi dalam pengukuran antropometrik dan komposisi badan, skor tekanan, aras kortisol dan kecergasan fizikal. PRT intensiti tinggi menggunakan tiub rintangan boleh memberi manfaat dalam meningkatkan aras DHEA yang dapat bertindak sebagai penanda biokimia tekanan.

Kata kunci: Senaman rintangan progresif; tekanan psikologi; kortisol; DHEA; kecergasan fizikal

INTRODUCTION

Stress is a very common problem among university students due to the transitional nature of university lifestyle. Stress affects mental health and causes many psychological problems such as depression, anxiety and tension. Mental stress can be defined as any emotional experiences, which can be measured through psychological, behavioral and biochemical changes (APA 2002). Aerobic exercise, resistance training and stress management programs have equal efficacy in reducing depression and anxiety level (Lyon 1995). Therefore, high intensity progressive resistance training (PRT) can be recommended as an alternative way to reduce stress among university students.

The neuroendocrine stress feedback system will be activated through hypothalamic-pituitary-adrenal (HPA) axis as response to a given stressor (Fairborther & Warn 2003). Stressors stimulate central nervous system (CNS) to release corticotropin-releasing hormone (CRH), which will then increases the secretion of adrenocorticotropin hormone (ACTH) from pituitary gland. ACTH stimulates the adrenal gland to release cortisol that can act as a stress indicator (De Vriendt et al. 2009). Other than cortisol, DHEA level can also reflect the biological situations of acute and chronic stress. DHEA is the most abundant steroid hormone found in human body and its highest concentration is around age 20-30. Decreased in DHEA(S) level occurred during stress conditions (Boudarene et al. 2002). A previous study showed that DHEA-S level increased significantly towards acute stress in healthy participants (Lennartsson et al. 2012).

Physical fitness such as muscle function and strength increased in healthy participants after resistance training (Zion et al. 2003). High intensity PRT in this study is a type of specific strength training that used resistant tube as resistance. The advantages of using resistant tube include improved coordination and balance; enable movement changes in multiple directions, easy to carry, cheap and suitable for all fitness level, from beginner to athlete (ACSM 2011). A previous study proposed that 12 weeks PRT reduced perceived stress and improved depression significantly in adults with Type 2 Diabetes Mellitus (Putri et al. 2012). High intensity resistance training also reduced cortisol level among healthy sedentary women as compared to low intensity resistance training (Marx et al. 2009). It was also reported to improve balance (Topp et al. 1993).

Although there were previous studies on the effects of resistance training on psychological stress, cortisol, DHEA and physical functions, however, limited studies on the effects of resistance training particularly using resistant tube done in this area. Besides, the changes of DHEA concentration in response to high intensity PRT is still unclear and it has received no attention in physically inactive or moderate active young male adults who have stress. In this regard, the positive effects of high intensity PRT on stress and physical fitness in this population should be taken into consideration. Hence, the purpose of this study is to examine the effects of high intensity PRT using resistant tubes on stress level, biochemical stress indicators and physical fitness among inactive and moderate active male university students.

METHODS

PARTICIPANTS

We employed purposive sampling method participant recruitment in this quasi-experimental study. The Research Ethic Committee of Universiti Kebangsaan Malaysia (UKM) approved the study protocol. The sample size was calculated using F test (ANOVA: Repeated measures, within-between interaction), G*Power software version 3.0.10. Significant level α ($\alpha = 0.05$) and power ($1 - \beta = 0.80$) was set and the calculated effect size was $f = 0.27$. The output showed that a total sample size of 30 participants was needed in this study.

Based on the student name lists of the Faculty of Health Sciences, UKM, a total of 72 male students were screened to meet the inclusion and exclusion criteria as shown in Table 1. After the screening, there were 15 students did not meet the inclusion criteria and 27 students declined to participate in this study. Total numbers of 30 male students who met the inclusion and exclusion criteria were agreed to participate. The risks and benefits of the study were explained to all participants and written informed consent was obtained prior to the data collection. Due to difficulty in getting participants to involve in intervention, participants who met the criteria were then allowed to choose to be either in the control or intervention group. 16 participants in control group (21.29 ± 1.86 yr) were instructed to continue their current lifestyle while the 14 participants in intervention group (21.50 ± 1.37 yr) were requested to follow a 10-weeks high intensity PRT took place in KTSN college. Data collections were done at baseline and after the 10-weeks training.

TABLE 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Moderate to very high stress level measured by using validated Perceived Stress Scale (PSS) questionnaire (Cohen et al. 1983)	Unable to perform required physical perfor-mance measures due to medical and musculo-skeletal problem
Not on continuous medication	Bone and/or head fracture
Inactive or have minimal ctive physical fitness measured through validated International Physical Activity Questionnaire (IPAQ) (Chu et al. 2012).	Physical disabilities

RESISTANCE TRAINING

PRT protocol was based on the FITT (frequency, intensity, time and type) principle (ACSM 2009). Participants in the intervention group were given a set of elastic resistant tubes for resistance training purpose. The training was conducted 3 times a week for 10 weeks. According to Folland and Williams (Folland & Williams 2007), significant changes in muscles adaptation can be observed after 8-12 weeks of resistance training. The intensity of the training was between 16-18 on the self-perceived Borg scales. Participants were required to perform three sets of 8-10 repetitions of exercises including: chest press, shoulder press, triceps extension, biceps curl, lateral shoulder raises, seated row, abdominal curl, chair squat, leg extension, leg curl, hip flexion and hip extension. Participants were instructed to perform one set of each exercise for the first two weeks, followed by two sets on the third and fourth weeks. Three sets of each exercise were performed in the following weeks. Group exercise session was performed once a week. Participants were supervised for few sessions at the beginning of training until every participant can perform the resistance exercises correctly and independently. They were then continued the exercise protocols in their respective homes and logbooks were given for compliance recording purpose.

ANTHROPOMETRY AND BODY COMPOSITION

Body weight, Body Mass Index (BMI), fat mass and muscle mass were assessed by bio-impedance method using body composition analyzer (TANITA SC-330, Japan). Body composition analyzer uses minor electric current to measure electric impedance. Participants were asked to remove socks and any metals such as jewellery, watch, necklace and ring before stepping on the weighing platform. Participants' heels have to be placed on the posterior electrode while the front foot on the anterior electrode before measurement. Results were then printed and recorded.

PSYCHOLOGICAL STRESS

Participants were assessed in terms of their psychological stress level by using self-administered Perceived Stress Score (PSS) (Cohen et al. 1983) and Student-Life Stress Inventory (SSI) (Gadzella 1994) questionnaires during pre and post-intervention. PSS is a most common psychological instrument used in measuring perceived stress and Malay version of PSS was used in this study. The reliability value of PSS Malay version is 0.82 and it showed adequate psychometric characteristics (Sami Abdo Radman Al-Dubai et al. 2012). While the reliability value of SSI Malay version is 0.88 (Tajularipin & Aminuddin 2009).

BIOCHEMICAL STRESS INDICATORS

For biochemical stress indicators measurement, a trained phlebotomist collected 10-15 ml blood samples in the morning following an over night fasting. Blood was centrifuged at 4000 rpm for 15 minutes (Hettich Rotofix 32A Centrifuge, UK). Serum was then aliquoted into appropriate appendorf tubes and stored at -20°C until analyses were done. The cortisol and DHEA concentration were determined by using commercially available ELISA kits (IBL International, Germany).

DYNAMIC BALANCE

Timed Up-and-Go (TUG) test was carried out to measure the total time in completing a series of task. On the word "GO," participants were asked to stand up from the chair and walked a distance for three meters with normal pace, turned around, walked back to the chair and sit down. Timing was stopped when the participants seated in the chair with their back leaning on the back of the chair.

MUSCLE STRENGTH

The maximum hand grip strength was measured by hand dynamometer (Sammons Preston Roylan, USA). Participants hold the dynamometer in the tested hand, with the arm positioned at the right angle and the elbow by the side of the body. The handle of the dynamometer was adjusted for a comfortable grip. Participants were required to grip as strong as possible in every grip. The test was repeated 3 times for each hand. The average readings were then recorded.

STATISTICAL ANALYSIS

The collected data was analyzed using Statistical Package of Social Science (SPSS) version 21. Baseline anthropometric measurements, PSS and SSI scores, the serum level of cortisol and DHEA, dynamic balance and handgrip strength between control and intervention groups were compared using unpaired T-test. While the time by group interaction for all parameters were evaluated using Generalized Linear Model (GLM). A two-tailed p-value less than 0.05 was taken as a significant value.

RESULTS

Out of 30 male participants, 13 of them were Malays and 17 were Chinese. The mean age for control participants was 21.50 ± 1.37 years old while intervention participants were 21.29 ± 1.86 years old respectively. No significant differences were found between control and intervention groups in anthropometric and body composition measurements, stress scores, stress biomarkers and physical fitness at baseline level. The means and standard deviations of all parameters were demonstrated in Table 2.

To examine the group differences in changes over time, mixed-split ANOVA was employed for all parameters between control and intervention groups at two time points (pre- and post-intervention). No significant group differences were found between control and intervention groups over time in all parameters except DHEA concentration (Table 3). DHEA concentration was significantly difference between control and intervention groups over time after the pre-intervention DHEA concentration was used as covariate ($F (1, 27) = 5.46$, $p = 0.03$, partial $\eta^2 = 0.17$) (Figure 1).

DISCUSSION

This study was aimed to investigate the effect of high intensity PRT using elastic tubes on psychological stress and physical fitness among inactive or moderate active young male university students. Male were chosen as participants in this study to avoid the fluctuations in hormone levels during menstruation cycles, which may cause inconsistency in results. The elastic tube was used in this study because of it is affordable, portable, easy and safe to use (Melchiorri &

TABLE 2. Pre-intervention data for anthropometric and body composition measurements, stress scores, stress biomarkers and physical fitness of control and intervention groups (presented as mean ± S.D)

Parameter	Control	Intervention	p-value
Body weight (kg)	58.49 ± 6.31	62.34 ± 13.06	0.33
BMI	20.00 ± 1.75	23.00 ± 4.91	0.11
Fat mass (kg)	8.07 ± 3.44	10.93 ± 7.91	0.23
Muscle mass (kg)	47.81 ± 3.40	48.73 ± 5.43	0.58
PSS score	20.25 ± 4.70	19.75 ± 4.55	0.35
SLSI score	122.25 ± 25.11	122.63 ± 29.89	0.99
Cortisol (ng/ml)	143.14 ± 22.04	124.58 ± 37.57	0.10
DHEA (ng/ml)	12.56 ± 2.25	11.75 ± 2.42	0.35
TUG (s)	9.59 ± 1.05	11.67 ± 3.64	0.07
Hand grip strength (kg)	41.19 ± 5.46	37.08 ± 6.67	0.08

BMI = Body Mass Index, PSS = Perceived Stress Scale, SLSI = Student Life Stress Inventory

TABLE 3. Time by Group interaction between control and intervention groups

Parameter	Mean ± S.D		Time by Group Interaction	
	Pre-Int.	Post-Int.	*F*	p
Anthropometry				
Body Weight (kg)				
Control	58.49 ± 6.31	58.96 ± 6.50	0.00	0.97
Intervention	62.34 ± 13.06	62.82 ± 12.89		
BMI				
Control	20.00 ± 1.75	20.00 ± 1.73	0.01	0.94
Intervention	23.00 ± 4.91	23.00 ± 4.75		
Body Composition				
Fat Mass (kg)				
Control	8.07 ± 3.44	7.76 ± 3.46	0.24	0.63
Intervention	10.93 ± 7.91	10.89 ± 7.74		
Muscle Mass (kg)				
Control	47.81 ± 3.40	48.54 ± 3.71	0.22	0.64
Intervention	48.73 ± 5.43	49.22 ± 5.33		
Stress Score				
PSS Score				
Control	20.25 ± 4.70	18.71 ± 4.08	0.79	0.38
Intervention	19.75 ± 4.55	17.29 ± 5.18		
SLSI Score				
Control	122.25 ± 25.11	122.43 ± 26.43	0.58	0.45
Intervention	122.63 ± 29.89	117.79 ± 20.37		
Stress Biomarker				
Cortisol (ng/ml)				
Control	143.14 ± 22.04	162.46 ± 15.71	1.74	0.20
Intervention	124.58 ± 37.57	157.46 ± 22.53		
Physical Fitness				
TUG (sec)				
Control	9.59 ± 1.05	8.93 ± 0.90	2.23	0.15
Intervention	11.67 ± 3.64	10.00 ± 2.97		
Hand Grip Strength (kg)				
Control	41.19 ± 5.46	42.86 ± 4.24	0.00	0.98
Intervention	37.08 ± 6.67	38.77 ± 5.63		

BMI = Body Mass Index, PSS = Perceived Stress Scale, SLSI = Student Life Stress Inventory

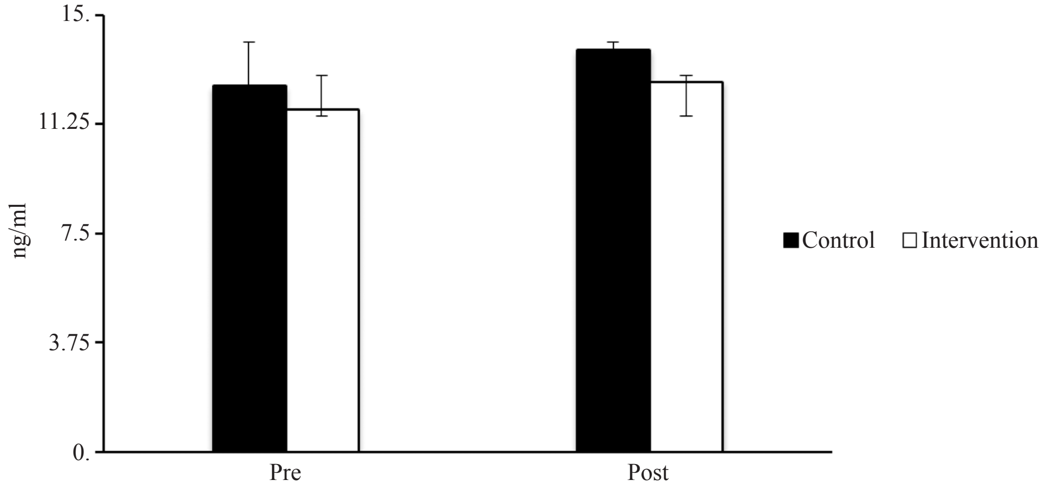

FIGURE 1. Time by Group interaction of DHEA level: F (1, 27) = 5.46, p = 0.03, partial $\eta^2 = 0.17$). Error bars = standard deviation, *p < 0.05 after adjusted for pre-DHEA level

Rainoldi 2011). The intensity of elastic resistance training using elastic tube can be controlled based on individual physical strength and it provides suitable resistance by increasing the resistance of elastic tubes gradually (Kwon et al. 2010).

Academic, personal and social problems could cause stress among university students and physical activity or exercise is always recommended as one of the strategies to manage stress. However, it has been reported that students carried out aerobic exercise or resistance training less than 3 times per week as well as spending half of their 30 hours sedentary activities for study purpose (Huang et al. 2003). Findings from this study showed that PSS and SSI scores did not differ significantly between control and intervention groups over time. However, PSS scores showed significant decrease trend after 10 weeks of intervention. It is likely that the participants may have different levels of stress during the intervention period, which caused by stressful events or circumstances that may disrupt the training (Bartholomew et al. 2008). Because the stress level of participants was measured at only two time points, the stress level during the intervention period was not clear. Therefore, it is suggested that the changes of psychological stress level, as well as cortisol and DHEA concentrations should be monitored throughout the intervention period. Whilst, poor nutritional intake, lack of sleep, consumption of alcohol and smoking are often correlated with stress. These factors may also affect the participants' adaptation to resistance training (Baum & Posluszny 1999). The decreasing trend in PSS and SSI scores over time may be due to the adaptation of participants towards items in the questionnaires and honesty in answering the questionnaires (Farah Fauzi et al. 2007).

Physiological effects could be induced in response to physical challenges such as exercise as well as psychological stress and cortisol is a hormone that always related to physical or psychological stress (Takai et al. 2004). Findings from the current study revealed that cortisol had no significant time by group interaction effect; however there was a non-significant increase trend in cortisol concentration among intervention participants after 10 weeks of resistance training. First, it was likely that physical stress produced by resistance training but not psychological stress stimulated the increase of hormonal response. Resistance training produced more stress and muscle breakdown, which lead to the increase secretion of cortisol (Tremblay et al. 2004). In turn, increased in cortisol level induced lipolysis and protein catabolism process that provides energy for muscles recovery and growth after exercise (Nindl et al. 2001). Secondly, participants may experience stress when withdrawing blood and it can also affect the cortisol concentration and the significance of the result. Therefore, it is suggested that encouragements and sufficient time should be given to participants to calm down and relax themselves before blood withdrawal process begin. Nevertheless, cortisol concentration of participants before and after 10 weeks high intensity PRT were still within normal range which is 50-230 ng/ml (138-635 nmol/L). This showed that participants did not experience serious stress that was able to increase the cortisol concentration beyond a normal range.

The present study found that DHEA concentration increased significantly between control and intervention groups after 10 weeks resistance training. This finding is supported by a research stated that DHEA concentration also increased significantly after resistance training (Copeland et al. 2002). DHEA is an ACTH-regulated adrenocortical steroid derived from cholesterol (Kalimi et al. 1994) and it can improve psychological wellbeing and its concentration increased significantly with improvement in mental health (McCraty et al. 1998). Its concentration is at peak around 20 years old and starts to decrease from the 25 years old. The average age of participants in this study was 21 years old and Orentreich et al. (1992) stated that young adults tend to have high capability in increasing hormonal response after exercise as compared to elderly population. Therefore, it can be explained that DHEA concentration increased significantly among young male students after 10 weeks resistance training. DHEA also demonstrates a protective effect against stress by reducing the exposure of active cortisol to target tissues by converting them into cortisone (Apostolova et al. 2005; Pelletier et al. 2007). Besides, DHEA also plays a role in suppressing glucocorticoid receptors and decreasing neurotoxic levels of glucocorticoids such as cortisol (Hu et al. 2000). Therefore, an increase in DHEA levels could amend the stress response.

TUG is a test that measures the functional mobility and dynamic balance of an individual. However, a significant difference in dynamic balance is difficult to be observed between control and intervention groups due to young adults already having high functional capacity compared to the elderly population (Bird et al. 2012). In addition, no significant changes in body weight, BMI, fat mass and muscle mass were demonstrated at the end of intervention period between control and intervention groups. Unchanged body weight and BMI may be due to the increase of muscle mass and it may offset the loss of fat mass in participants. Body mass may already shift from fat to muscles after resistance training (Hansen et al. 2011). Besides, intervention participants who were originally inactive or less active were likely to increase their caloric intake or changed their eating habits as a result of resistance training. Thus, it may cause no significant changes in body composition measurements at the end of the study. Resistance training also has positive effect on muscle strength (Arimi et al. 2012) and increased muscle strength without any changes on muscle mass may suggest that the improvement was predominantly attributed to the neural adaptation (Hansen et al. 2011).

The current study does have limitations. Self-reported practice may not be accurate. There may be a bias where participants who did not complete all the sets and repetitions of exercises as requested but still recorded in the logbooks given. Besides, testosterone should also be taken into account, as male participants were involved in this study and this anabolic hormone plays an important role in the growth and maintenance of skeletal muscle, bone and red blood cells in respect to exercise (Zitsmann & Nieschlag 2001). Another limitation is the caloric or dietary intakes of participants were not recorded. Therefore, it is suggested that in future studies, dietary intake of participants can be included in order to determine its effect and interaction with resistance training on psychological stress, stress biomarkers and physical functions.

CONCLUSION

In conclusion, our study suggested that high intensity PRT using resistant tube significantly improved muscle strength and has potential in increasing DHEA concentration among inactive or minimally active young male university students who have stress. The increase in DHEA level is associated with good mental health. Therefore, other than aerobic exercise, high intensity PRT using resistant tube could be an alternative exercise in managing stress and improving mental and physical health among young adults.

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REFERENCES

American College of Sports Medicine (ACSM). 2009. ACSM's Guidelines for Exercise Testing and Prescription, 8th ed. MD: Lippincott Williams & Wilkins.

American College of Sports Medicine (ACSM). 2011. Selecting and effectively using rubber band resistance exercise. Available at: http://www.acsm.org/docs/brochures/selecting-and-effectively-using-rubber-band-resistance-exercise.pdf

American Psychological Association (APA). 2002. Glossary for psychological terms. Available at: http://www.apa.org/research/action/glossary.aspx

Apostolova, G., Schweizer, R.A.S., Balazs, Z., Kostadinova, R.M. & Odermatt, A. 2005. Dehydroepiandrosterone inhibits the amplification of glucocorticoid action in adipose tissue. *American Journal of Physiology* 288: E957-E964.

Arimi Fitri Mat Ludin, Loke, S.C., Fiatarone Singh, M.A., Norliza, Z., Wong, T.W. & Vytialingam, N. 2012. Functional capacity of middle age and elderly with type 2 diabetes mellitus following 16 weeks home base progressive resistance training. *Proceeding of 1ST World Congress On Healthy Ageing 2012*.

Bartholomew, J.B., Stults-Kolehmainen, M.A., Elrod, C.C. & Todd, J.S. 2008. Strength gains after resistance training: the effect of stressful, negative life events. *Journal of Strength and Conditioning Research* 22(4): 1215-1221.

Baum, A. & Posluszny, D.M. 1999. Health psychology: mapping biobehavioral contributions to health and illness. *Annual Review of Psychology* 50: 137-164.

Bird, M.L., Hill, K.D. & Fell, J.W. 2012. A randomized controlled study investigating static and dynamic balance in older adults after training with pilates. *Archive of Physical Medicine and Rehabilitation* 93: 43-49.

Boudarene, M., Legros, J.J. & Timsit-Berthier, M. 2002. Study of stress response: role of anxiety, cortisol and DHEA. *Encephale* 28: 139-146.

Chu, A.H. & Moy, F.M. 2012. Reliability and validity of the Malay International Physical Activity Questionnaire (IPAQ-M) among a Malay Population in Malaysia. *Asia-Pacific Journal of Public Health.*

Cohen, S., Kamarck, T. & Mermelstein, R. 1983. A global measure of perceived stress. *Journal of Health and Social Behavior* 24: 386-396.

Copeland, J.L., Consitt, L.A. & Tremblay, M.S. 2002. Hormonal responses to endurance and resistance exercise in females aged 19-69 years. *Journal of Gerontology* 57A(4): 158-165.

De Vriendt, T., Moreno, L.A. & De Henauw, S. 2009. Chronic stress and obesity in adolescents: scientific evidence and methodological issues for epidemiological research. *Nutrition, Metabolism and Cardiovascular Disease* 19: 511-519.

Fairbrother, K & Warn, J. 2003. Workplace dimensions, stress & job satisfaction. *Journal of Managerial Psychology* 18(1): 8-21.

Fauzi, F., Arimi Fitri Mat Ludin, Mahadir, A. & Kamarul Zaman, M. 2007. Kesan senaman aerobik terhadap penanda stres terpilih di kalangan pelajar semasa musim peperiksaan akademik. *Jurnal Sains Kesihatan Malaysia* 4(2): 27-37.

Folland, J.P. & Williams, A.G. 2007. The adaptations to strength training. Morphological and neurological contributions to increasing strength. *Sports Medicine* 37(2): 145-168.

Gadzella, B.M. 1994. Student-life stress inventory. *Psychological Reports* 74: 395-402.

Hansen, E., Landstad, B.J., Brønn, R., Gundersen, K.T. & Svebak, S. 2011. Exercise-induced changes in body fat, upper leg skeletal muscle area, BMI and body weight in overweight people with risk of developing type 2 diabetes. *Acta Kinesiologiae Universitatis Tartuensis* 17: 66-79.

Hu, Y., Cardounel, A., Gursoy, E., Anderson, P. & Kalimi, M. 2000. Anti-stress effects of dehydroepiandrosterone: protection of rats against repeated immobilization stress-induced weight loss, glucocorticoid receptor production, and lipid peroxidation. *Biochemical Pharmacology* 59: 753-762.

Huang, T.T., Harris, K.J., Lee, R.E., Nazir, N., Born, W. & Kaur, H. 2003. Assessing overweight, obesity, diet, and physical activity in college students. *Journal of American College Health* 52(2): 83-86.

Kalimi, M., Shafagoj, Y., Loria, R., Padgett, D. & Regelson, W. 1994. Anti-glucocorticoid effects of dehydroepiandrosterone (DHEA). *Molecular Cellular Biochemistry* 131: 99-104.

Kwon, H.R., Han, K.A., Ku, Y.H., Ahn, H.J., Koo, B.K., Kim, H.C. & Min, K.W. 2010. The effects of resistance training on muscle and body fat mass and muscle strength in Type 2 diabetic women. *Korean Diabetes Journal* 34: 101-110.

Lennartsson, A.K., Kushnir, M.M., Bergquist, J. & Jonsdottir, I.H. 2012. DHEA and DHEA-S response to acute psychosocial stress in healthy men and women. *Biology Psychology* 90(2): 143-149.

Lyon, LA. 1995. *A comparative analysis of aerobic conditioning, resistance training and a structured stress management program in attenuation of the adult psychophysiological response to cognitive stress.* College Park: University of Maryland.

Marx, J.O., Raratamess, N.A., Nindl, B.C., Gotshalk, L.A., Volek, J.S., Dohi, K., Bush, J.A., Go'mez, A.L., Mazzetti, S.A., Fleck, S.J., Hakkinen, K., Newton, R.U. & Kraemer, W.J. 2009. Low-volume circuit versus high-volume periodized resistance training in women. *Medicine and Science in Sports and Exercise* 635-643.

McCraty, R., Chopin, B.B., Rozman, D., Atkinso, M. & Watkins, A.D. 1998. The impact of a new emotional self-management program on stress, emotions, heart rate variability, DHEA and cortisol. *Integrative Physiological and Behavioral Science* 33(2): 151-170.

Melchiorri, G. & Rainoldi, A. 2011. Muscle fatigue induced by two different resistances: Elastic tubing versus weight machines. *Journal of Electromyography and Kinesiology* 21(6): 954-959.

Nindl, B.C., Kraemer, W.J., Deaver, D.R., Peters, J.L., Marx, J.O., Heckman, J.T. & Loomis, G.A. 2001. LH secretion and testosterone concentrations are blunted after resistance exercise in men. *Journal of Applied Physiology* 91: 1251-1258.

Orentreich, N., Brind, J.L. & Vogelman, J.H. 1992. Long-term longitudinal measurements of plasma dehydroepiandrosterone sulfate in normal men. *Journal of Clinical Endocrinology and Metabolism* 75: 1002-1004.

Pelletier, G., Luu-The, V., Li, S., Bujold, G. & Labrie, F. 2007. Localization and glucocorticoid regulation of 11β-hydroxysteroid dehydrogenase types 1 mRNA in the male mouse forebrain. *Neuroscience* 145: 110-115.

Putiri, A.L., Lovejoy, J.C., Gillham, S., Sasagawa, M., Bradley, R. & Sun, G.C. 2012. Psychological effects of Yi Ren Medical Qi Gong and progressive resistance training in adults with type 2 diabetes mellitus: A randomized controlled trial pilot study. *Alternative Therapies in Health and Medicine* 18(1): 30-34.

Roberts, C.K., Croymans, D.M., Aziz, N., Butch, A.W. & Lee, C.C. 2013. Resistance training increases SHBG in overweight/obese, young men. Metabolism. Available at http://www.ncbi.nlm.nih.gov/pubmed/23318050

Sami Abdo Radman Al-Dubai, Mustafa Ahmed, Gopal, K. & Sulaiman, N.A. 2012. Factor structure and reliability of the Malay version of the perceived stress scale among Malaysian medical students. *Malaysian Journal of Medicine and Science* 19(3): 43-49.

Tajularipin Sulaiman & Aminuddin Hassan. 2009. The level of stress among students in urban and rural high schools in Malaysia. *European Journal of Social Sciences* 10(2): 43-65.

Takai, N., Yamaguchi, M., Aragaki, T., Eto, K., Uchihashi, K. & Nishikawa, Y. 2004. Effect of psychological stress on the salivary cortisol and amylase levels in healthy young adults. *Archive of Oral Biology* 49(12): 963-968.

Topp, R., Mikesky, A., Wigglesworth, J., Holt, W. Jr. & Edwards, J.E. 1993. The effect of a 12-week dynamic resistance strength training program on gait velocity and balance of older adults. *Gerontologist* 33(4): 501-506.

Tremblay, M.S., Copeland, J.L. & Helder, W.V. 2004. Effect of training status and exercise mode on endogenous steroid hormones in men. *Journal of Applied Physiology* 96: 531-539.

Zion, A.S., De Meersman, R., Diamond, B.E. & Bloomfield, D.M. 2003. A home-based resistance training program using elastic bands for elderly patients with orthostatic hypotension. *Clinical Autonomic Research* 13(4): 286-292.

Zitzmann, M. & Nieschlag, E. 2001. Testosterone levels in healthy men and the relation to behavioral and physical characteristics: facts and constructs. *European Journal of Endocrinology* 144(3): 183-197.

Arimi Fitri Mat Ludin
Lau Hui Jin
Suhaniza Sairan
Biomedical Science Program
School of Diagnostic and Applied Health Sciences
Faculty of Health Sciences
Universiti Kebangsaan Malaysia
Jalan Raja Muda Abdul Aziz
50300 Kuala Lumpur, Malaysia

Mahadir Ahmad
Clinical Psychology Program
School of Health Care Sciences
Faculty of Health Sciences
Universiti Kebangsaan Malaysia
Jalan Raja Muda Abdul Aziz
50300 Kuala Lumpur, Malaysia

Nor Farah Mohd Fauzi
Occupational Therapy Program
School of Rehabilitation Science
Faculty of Health Sciences
Universiti Kebangsaan Malaysia
Jalan Raja Muda Abdul Aziz
50300 Kuala Lumpur, Malaysia

Corresponding author: Arimi Fitri Mat Ludin
Email address: arimifitri@edu.ukm.my / arimifitri.fsk.ukm@gmail.com
Tel.: +603 9389 8043
Fax: +603 2692 9032

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