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***Retrospective Cohort Study***

Rationale and design of the cardiorespiratory fitness and hospitalization events in armed forces study in Eastern Taiwan

Lin GM *et al*. Rationale and design of the CHIEF study

**Gen-Min Lin, Yi-Hwei Li, Chung-Jen Lee, Jeng-Chuan Shiang, Ko-Huan Lin, Kai-Wen Chen, Yu-Jung Chen, Ching-Fen Wu, Been-Sheng Lin, Yun-Shun Yu, Felicia Lin, Fun-Yin Su, Chih-Hung Wang**

**Gen-Min Lin, Jeng-Chuan Shiang, Ko-Huan Lin, Kai-Wen Chen, Yu-Jung Chen, Been-Sheng Lin, Yun-Shun Yu, Felicia Lin, Chih-Hung Wang,** Department of Medicine, Hualien-Armed Forces General Hospital, Hualien 971, Taiwan

**Gen-Min Lin, Chih-Hung Wang,** Department of Medicine, Tri-Service General Hospital, and National Defense Medical Center, Taipei 114, Taiwan

**Gen-Min Lin, Yi-Hwei Li, Fun-Yin Su,** Department of Public Health, Tzu-Chi University, Hualien 970, Taiwan

**Chung-Jen Lee,** Department of Nursing, Tzu-Chi College of Technology, Hualien 970, Taiwan

**Ching-Fen Wu**, Department of Medicine, Mennonite Christian Hospital, Hualien 970, Taiwan

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**Correspondence to: Gen-Min Lin, MD, MPH**, Department of Medicine, Hualien-Armed Forces General Hospital, No. 630, Jiali Rd. Xincheng Township, Hualien 971, Taiwan. [farmer507@yahoo.com.tw](mailto:farmer507@yahoo.com.tw)

**Telephone:** +886-38260601

**Fax:** +886-38261370

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**Abstract**

**AIM:** To investigate the association between cardiorespiratory fitness and hospitalization events in a cohort of large voluntary arm forces in Taiwan.

**METHODS:** Thecardiorespiratory fitness and hospitalization events in armed forces (CHIEF) is a retrospective cohort consisting of more than 4000 professional military members aged 18-50 years in eastern Taiwan. All participants received history taking, physical examination, chest radiography, 12-lead electrocardiography, blood tests for cell counts and fasting glucose, lipid profiles, uric acid, renal function and liver function in the Hualien Armed Forces General Hospital during 2014. In addition, participants were required to undergo two indoor resistant exercise tests including 2-min push-up and 2-min sit-up, both scored by infrared sensing, and one outdoor endurance 3000-m none weight-bearing running test, the main indicator of cardiorespiratory fitness in the Military Physical Training and Testing Center in eastern Taiwan in 2014.

**RESULTS:** Hospitalization events for cardiovascular disease, acute kidney injury, rhabdomyolysis, severe infectious disease, acute psychiatric illness, diabetes, orthopedic surgery and mortality will be identified in the National Insurance Research Database for 10 years.

**CONCLUSION:** CHIEF will be among the largest eastern Asian armed forces cohort, in which physical status was strictly evaluated to follow up the hospitalization events for severe illness.

**Key words:** Cardiorespiratory fitness; Hospitalization; Voluntary armed forces

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**Core tip:** Whether rigorous physical trainings including endurance and resistance exercises for professional young adults in armed forces associated with well or poor cardiovascular outcomes in their middle ages is unknown. In addition, several unhealthy factors such as cigarette smoking and depressive mood are prevalent among arm forces, which may affect the physical performance and increase the risk of hospitalization for severe illness. In this case, we will investigate the association of cardiorespiratory fitness with hospitalization events in a retrospective cardiorespiratory fitness and hospitalization events in armed forces cohort consisting of about 4000 professional military members aged 18-50 years in eastern Taiwan for more than 10 years.

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**INTRODUCTION**

Professional military members are required to take regular rigorous physical trainings including endurance and resistance exercise to maintain their outstanding fitness. Frequent exercise training and well physical fitness have been associated with lower risk of cardiovascular disease and mortality in the general population[1-3]. However, current evidence showed conflicting results regarding the cardiovascular outcomes in those taking repetitive strenuous exercises[4,5]. For instance, cardiac remodeling such as left ventricular muscle hypertrophy, chamber dilatation, mitral valve regurgitation, and arrhythmia, which have been well regarded as poor prognostic predictors of acute cardiac events among patients with conventional atherosclerotic risk factors are commonly present in elite athletes[6-8]. Whether these physiological cardiac adaptations to repetitive vigorous training on future cardiovascular disease and mortality are beneficial or hazardous to armed forces remain unknown. In addition, several unhealthy behaviors and environments such as cigarette smoking, alcohol intake, stress, insomnia, and depressive mood are prevalent among arm forces, which may affect the physical performance by reducing cardiopulmonary function and increase the risk of hospitalization for acute illness[9,10]. However there were few studies using large military cohorts, particularly of Asian young adults, with detailed data of demographics, laboratory exams, and cardiopulmonary function evaluations at baseline, to follow up the incidence of cardiovascular disease and other severe illness events. Therefore the aim of our study is to retrospectively investigate the association between cardiorespiratory fitness and hospitalization events in a large voluntary arm forces cohort in eastern Taiwan.

**MATERIALS AND METHODS**

***Study population***

Thecardiorespiratory fitness and hospitalization events in armed forces (CHIEF) is a retrospective cohort consisting of voluntary military members aged 18-50 years in eastern Taiwan during 2014.

***Measurements of the health examinations***

All participants had to undergo physical examinations, anthropometric measurements for height, weight, and waist circumference at standing position, hemodynamic status including pulse rate and blood pressures, which were automatically measured by the PARAMA TECH FT-201 blood pressure monitor over right upper arm at sitting position, after taking rest for at least 15 min, chest radiography [posteroanterior (PA) standing view], 12-lead electrocardiography which was interpreted mainly according to the computerized Minnesota Code classification system[11], urinalysis, blood tests for cell counts and concentrations of fasting glucose, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglycerides, serum uric acid, blood urea nitrogen, creatinine, estimated glomerular filtration rate (eGFR) which was defined on the basis of the Chronic Kidney Disease Epidemiology Collaboration equation[12], aspartate transaminase (AST), alanine transaminase (ALT), and surface antigen of viral hepatitis B in the Hualien Armed Forces General Hospital where is the only military referral center for the professional armed forces in Hualien, Taiwan to perform the whole body health exams in 2014 (Figure 1). With regard to history taking, all participants were asked to self-report a questionnaire including demographic information, personal and third degree relatives medical history, current cigarette smoking status, current alcohol intake status, current betel chewing status, frequency of exercise persisting for at least 30 min in the past half year (never, occasionally, 0-1 time per week, 3-5 times per week), ever experienced any discomfort related to exercise (dizziness, chest tightness, dyspnea, or palpitation), and Brief Symptom Rating Score (BSRS-5)[13,14] which is a 5-item Likert scale [scores of 0 (none), 1 (mild), 2 (moderate), 3 (severe), 4 (extremely severe)] for measurement of the severity of psychological distress. A higher score indicates poorer mental health[13]. The full scale contained the following five items of psychopathology: (1) feeling tense or keyed up (anxiety); (2) feeling low in mood (depression); (3) feeling easily annoyed or irritated (hostility); (4) feeling inferior to others (interpersonal hypersensitivity: inferiority); and (5) having trouble falling asleep (insomnia); and an additional question, “Do you have any suicide ideation?” was added at the end of the questionnaire.

***Measurements of the physical fitness***

In addition, participants were also required to undergo two indoor resistant exercise tests including 2-min push-up and 2-min sit-up and one outdoor endurance 3000-m none weight-bearing running exercise test, the main indicator of cardiorespiratory fitness in the Military Physical Training and Testing Center in eastern Taiwan during 2014. Both 2-min push-up and 2-min sit-up contests were computerized scoring and whole courses were recorded by video. The procedure of 2-min push-up was scored only when the participants’ body upward movement achieving the initial resting set height levels of shoulder and buttock simultaneously detected by infrared sensors (Figure 2A). The test would be early aborted once either elbows or knees touched down on the ground before time out. The procedure of 2-min sit-up was scored only if participants’ body bended forward and elbows blew the touch sensors on both thighs (Figure 2B). With regard to 3000-m none weight-bearing running exercise test, whole course was recorded by video as well. All 3000-m none weight-bearing running tests were only allowed to be held at 16:00 p.m. when the risk coefficient of heat stroke, the product of outdoor temperature (ºC) and relative humidity (%) × 0.1, was less than 40 or it was not raining.

***Follow-up for the outcome of interests***

After 2014, those retained in annual health or physical fitness exams will be followed up longitudinally. The outcome of interest will be the hospitalization events for cardiovascular disease, acute kidney injury, rhabdomyolysis, severe infectious disease, acute psychiatric illness, type 2 diabetes mellitus, orthopedic surgery, and mortality respectively. Hospitalization events will be identified in the National Insurance Research Database and followed up for at least 10 years. This study was approved by the Institutional Review Board of the Mennonite Christian Hospital in Hualien, Taiwan and written informed consent was obtained from all participants.

***Statistical analysis***

The armed forces in eastern Taiwan who did not receive health examinations or undergo exercise tests in the index centers of Hualien during 2014 were excluded. Figure 3 shows the flow diagram to select the CHIEF study cohort. Demographic characteristics and exercise performances of men and women were reported as mean ± standard deviation (SD) or percent for continuous and categorical variables, respectively. The analysis will use the time for follow-up at January 1, 2014 with censoring at first occurrence of hospitalization events for specific severe illness, death, or end of follow-up (December 31, 2024). Kaplan-Meier analysis will be used to assess the sex-specific association of each exercise test performances (2-min push-up, 2-min sit-up, and 3000-m none weight-bearing running) with incident hospitalization events for specific severe illness. Cox proportional hazard regression analyses will be used to assess the sex-specific multivariable association between each exercise test performance and incident hospitalization events, adjusting for potential confounders. A 2-tailed value of *P*-value < 0.05 will be considered significant.

**RESULTS**

The historical CHIEF cohort consists of 4080 participants who received both health exams and underwent at least one exercise test during 2014. The administrative rates for 2-min sit-up, 2-min push-up, and 3000-m none weight-bearing running test were 99.5%, 98.8% and 88.6%, respectively. The descriptive statistics of baseline profiles, medical and family history, laboratory and 12-lead electrocardiographic findings, BSRS scores, and each exercise test performance of men and women were shown in Tables 1-4 respectively. Of these participants, men accounted for about 89.9% and the mean age of men and women were about 29 and 28 years, respectively.

**DISCUSSION**

Previous studies have demonstrated the benefit of leisure time exercise which may reduce inflammatory response, viscosity, and the risk of cardiovascular disease in the general population[15-18]. However, it is not clear the relationship of what kinds of exercise, how the dosing of exercise, and the performance of physical fitness in young adults with future health status in their middle age. In addition, for a population with rigorous exercise training daily for work such as athletes and professional military members, the question of exercise training and physical fitness on the health status has not been answered yet, since there were too few large cohort studies to investigate the association. Therefore the CHIEF study will be one of the largest retrospective military cohort ever in the world to retrospectively follow up the severe illness events.

In CHIEF, the anthropometric profile of men was characterized by an average overweight value defined by the body mass index criteria for eastern Asian individuals (> 24.0 kg/m2), but within a non-obese waist circumference limit defined to be < 85 cm for Asian male populations[19,20]. This may reflect that muscle mass may account for a higher proportion of body weight in men, which was also supported by a higher proportion of electrocardiographic left ventricular hypertrophy (17%) in men. In contrast, both levels of body mass index and waist circumference in women were within non-obese levels suggested for Asian female populations[20]. Unlike elite athletes, many unhealthy behaviors such as cigarette smoking and alcohol consumption were prevalent in men (about 40%) and in women (10%-20%). In addition, about 40% of men reported mild to extremely severe depression or anxiety and 50% of women reported those negative psychological symptoms. Because of the specialty of armed forces, all these confounders should be taken into account the association between physical fitness and severe illness events.

Push-up and sit-up performance were used to assess musculoskeletal fitness. Push-up exercise is a strengthening exercise for building up strength and endurance in the muscles of the upper arm and shoulders, and sit-up exercise is performed to enhance abdominal muscular endurance. Mota *et al*[21] showed that low push-up and sit-up test performance is associated with increased risk for obesity and metabolic risk in adolescent girls. Furthermore, Katzmarzyk *et al*[22] found that sit-up but not push-up performance is predictive of mortality in the Canadian population. Performance in 3000-m (middle distance) running mainly depends on maximal aerobic power (VO2max)[23], which are related to several physiological parameters including maximal oxygen uptake, running economy, velocity at 4 mmol/L blood lactate concentration, and the minimal velocity at which VO2max occurs[24-28]. Accordingly, the performance of 3000-m none weight-bearing running test in armed forces could be regarded as a good surrogate for their cardiorespiratory fitness. As is known, adolescent cardiorespiratory fitness has been associated with adult fatness[29]. Several previous studies in the Western countries demonstrated that superior cardiorespiratory fitness may be associated with lower risk of hospitalization events for incident hypertension, diabetes mellitus, coronary heart disease, stroke, cataract, and diverticular complications[30-35]. Moreover, a relationship between cardiorespiratory fitness and all-cause and cardiovascular mortality has been well established in the general population[1-3]. On the contrary, outstanding cardiorespiratory fitness is highly related to rigorous exercise training which may lead to hazardous cardiovascular events such as sudden death and severe cardiac arrhythmia, rhabdomyolysis, and orthopedic illness in armed forces[36]. It is important to know how to prevent exercise related lethal complications and to obtain the best physical fitness.

The strength of the study includes that: (1) the data of the historical cohort is complete since both whole body health examinations and physical exercise tests are scheduled for all professional military members annually unless those who receive these examinations elsewhere; (2) the procedures of health examinations and physical exercise tests are standardized and performed in central labs which could avoid systemic bias completely; (3) as compared with previous studies for the association of physical fitness with severe illness, the baseline data of CHIEF includes not only demographic characteristics but also a series of laboratory and imaging findings, which could be further adjusted to prevent potential bias; and (4) both health examinations and physical exercise tests will be held annually that provide the opportunity for us to follow up the interval change of the physical fitness and investigate the association with severe illness. On the contrary, we have several limitations in the study. First, there were about one third (33.5%) of the military members in armed forces who received health examinations but did not undergo any physical exercise test in Hualien during 2014. Although the baseline characteristics of drop-out individuals were similar to those enrolled in CHIEF, we could not completely exclude the selection bias. Second, women account for only 10% of the CHIEF cohort and we may not have enough power to make a conclusion at last. Third, since CHIEF is a retrospective study, some potential confounders such as systemic inflammatory markers, cardiac biomarkers, nutritional support, diet, and the type of daily regular exercise trainings performed, which may affect the physical performance and hospitalization events for severe illness, will not be available without prospective collection.

In summary, physical fitness as an independent predictor of mortality and cardio-metabolic risk in the general population has not been confirmed in young military members of armed forces who have many traditional vascular risk factors. The CHIEF study is thus designed to be one of the largest military cohorts in the world and will retrospectively investigate the association of each physical fitness performance, the interval change of each physical fitness, and incident hospitalization events for severe illness. The result of CHIEF could be applied to the military members in armed forces to improve the physical trainings effectively and prevent the adverse effect related to heavy exercises in the future.

**COMMENTS**

***Background***

Professional military members are required to take regular rigorous physical trainings to maintain their physical fitness. However, several unhealthy factors such as cigarette smoking are prevalent among arm forces, which may affect the exercise performance and increase the risk of severe illness.

***Research frontiers***

Frequent exercise training and well physical fitness have been associated with lower risk of cardiovascular disease and mortality in the general population. Current evidence in the Western countries showed conflicting results for the cardiovascular outcomes in those taking repetitive strenuous exercises.

***Innovations and breakthroughs***

There were few studies using large military cohorts, particularly of Asian young adults, with detailed data of demographics, laboratory exams, and cardiopulmonary function evaluations at baseline, to follow up the incidence of cardiovascular disease and other severe illness events such as infectious and orthopedic disease. Thecardiorespiratory fitness and hospitalization events in armed forces (CHIEF) is a retrospective cohort consisting of more than 4000 professional military members aged 18-50 years in eastern Taiwan. CHIEF will be among the largest eastern Asian armed forces cohort, in which physical status was strictly evaluated to follow up the hospitalization events for specific severe illness.

***Applications***

The result of CHIEF could be applied to the military members in armed forces to improve the physical trainings effectively and prevent the adverse effect related to heavy exercises in the future.

***Peer-review***

The authors present here the protocol of a study about cardiorespiratory fitness in a military population. It is well written and seems to me it will make a fine study when finished.

**REFERENCES**

1 **Wei M**, Kampert JB, Barlow CE, Nichaman MZ, Gibbons LW, Paffenbarger RS, Blair SN. Relationship between low cardiorespiratory fitness and mortality in normal-weight, overweight, and obese men. *JAMA* 1999; **282**: 1547-1553 [PMID: 10546694 DOI: 10.1001/jama.282.16.1547]

2 **Lee DC**, Sui X, Artero EG, Lee IM, Church TS, McAuley PA, Stanford FC, Kohl HW, Blair SN. Long-term effects of changes in cardiorespiratory fitness and body mass index on all-cause and cardiovascular disease mortality in men: the Aerobics Center Longitudinal Study. *Circulation* 2011; **124**: 2483-2490 [PMID: 22144631 DOI: 10.1161/CIRCULATIONAHA.111.038422]

3 **Artero EG**, Jackson AS, Sui X, Lee DC, O'Connor DP, Lavie CJ, Church TS, Blair SN. Longitudinal algorithms to estimate cardiorespiratory fitness: associations with nonfatal cardiovascular disease and disease-specific mortality. *J Am Coll Cardiol* 2014; **63**: 2289-2296 [PMID: 24703924 DOI: 10.1016/j.jacc.2014.03.008]

4 **Schnohr P**, O'Keefe JH, Marott JL, Lange P, Jensen GB. Dose of jogging and long-term mortality: the Copenhagen City Heart Study. *J Am Coll Cardiol* 2015; **65**: 411-419 [PMID: 25660917 DOI: 10.1016/j.jacc.2014.11.023]

5 **Armstrong ME**, Green J, Reeves GK, Beral V, Cairns BJ. Frequent physical activity may not reduce vascular disease risk as much as moderate activity: large prospective study of women in the United Kingdom. *Circulation* 2015; **131**: 721-729 [PMID: 25688148 DOI: 10.1161/CIRCULATIONAHA.114.010296]

6 **Spirito P**, Pelliccia A, Proschan MA, Granata M, Spataro A, Bellone P, Caselli G, Biffi A, Vecchio C, Maron BJ. Morphology of the "athlete's heart" assessed by echocardiography in 947 elite athletes representing 27 sports. *Am J Cardiol* 1994; **74**: 802-806 [PMID: 7942554 DOI: 10.1016/0002-9149(94)90439-1]

7 **Pelliccia A**, Kinoshita N, Pisicchio C, Quattrini F, Dipaolo FM, Ciardo R, Di Giacinto B, Guerra E, De Blasiis E, Casasco M, Culasso F, Maron BJ. Long-term clinical consequences of intense, uninterrupted endurance training in olympic athletes. *J Am Coll Cardiol* 2010; **55**: 1619-1625 [PMID: 20378081 DOI: 10.1016/j.jacc.2009.10.068]

8 **Engel DJ**, Schwartz A, Homma S. Athletic Cardiac Remodeling in US Professional Basketball Players. *JAMA Cardiol* 2016; **1**: 80-87 [DOI: 10.1001/jamacardio.2015.0252]

9 **Pettersson K**, Saers J, Lindberg E, Janson C. Sleep disturbances among Swedish soldiers after military service abroad. *Ups J Med Sci* 2016; **121**: 65-69 [PMID: 26959327 DOI: 10.3109/03009734.2016.1144663]

10 **Toblin RL**, Anderson JA, Riviere LA, McGurk D, Sipos ML. The Impact of Unit Membership on Smoking Among Soldiers. *Mil Med* 2016; **181**: 16-20 [PMID: 26741472 DOI: 10.7205/MILMED-D-15-00063]

11 **Blackburn H**, Keys A, Simonson E, Rautaharju P, Punsar S. The electrocardiogram in population studies. A classification system. *Circulation* 1960; **21**: 1160-1175 [PMID: 13849070 DOI: 10.1161/01.CIR.21.6.1160]

12 **Levey AS**, Stevens LA. Estimating GFR using the CKD Epidemiology Collaboration (CKD-EPI) creatinine equation: more accurate GFR estimates, lower CKD prevalence estimates, and better risk predictions. *Am J Kidney Dis* 2010; **55**: 622-627 [PMID: 20338463 DOI: 10.1053/j.ajkd.2010.02.337]

13 **Lee MB**, Liao SC, Lee YJ, Wu CH, Tseng MC, Gau SF, Rau CL. Development and verification of validity and reliability of a short screening instrument to identify psychiatric morbidity. *J Formos Med Assoc* 2003; **102**: 687-694 [PMID: 14691593]

14 **Chen WJ**, Chen CC, Ho CK, Chou FH, Lee MB, Lung F, Lin GG, Teng CY, Chung YT, Wang YC, Sun FC. The relationships between quality of life, psychiatric illness, and suicidal ideation in geriatric veterans living in a veterans' home: a structural equation modeling approach. *Am J Geriatr Psychiatry* 2011; **19**: 597-601 [PMID: 21606903 DOI: 10.1097/JGP.0b013e3181faec0e]

15 **Koenig W**, Sund M, Döring A, Ernst E. Leisure-time physical activity but not work-related physical activity is associated with decreased plasma viscosity. Results from a large population sample. *Circulation* 1997; **95**: 335-341 [PMID: 9008446 DOI: 10.1161/01.CIR.95.2.335]

16 **Wagner A**, Simon C, Evans A, Ferrières J, Montaye M, Ducimetière P, Arveiler D. Physical activity and coronary event incidence in Northern Ireland and France: the Prospective Epidemiological Study of Myocardial Infarction (PRIME). *Circulation* 2002; **105**: 2247-2252 [PMID: 12010905 DOI: 10.1161/01.CIR.0000016345.58696.4F]

17 **Rothenbacher D**, Hoffmeister A, Brenner H, Koenig W. Physical activity, coronary heart disease, and inflammatory response. *Arch Intern Med* 2003; **163**: 1200-1205 [PMID: 12767957 DOI: 10.1001/archinte.163.10.1200]

18 **Sofi F**, Capalbo A, Cesari F, Abbate R, Gensini GF. Physical activity during leisure time and primary prevention of coronary heart disease: an updated meta-analysis of cohort studies. *Eur J Cardiovasc Prev Rehabil* 2008; **15**: 247-257 [PMID: 18525378 DOI: 10.1097/HJR.0b013e3282f232ac]

19 **Lin GM**, Li YH, Lin CL, Wang JH, Han CL. Relation of body mass index to mortality among Asian patients with obstructive coronary artery disease during a 10-year follow-up: a report from the ET-CHD registry. *Int J Cardiol* 2013; **168**: 616-620 [PMID: 23465238 DOI: 10.1016/j.ijcard.2013.01.204]

20 **Guan X**, Sun G, Zheng L, Hu W, Li W, Sun Y. Associations between metabolic risk factors and body mass index, waist circumference, waist-to-height ratio and waist-to-hip ratio in a Chinese rural population. *J Diabetes Investig* 2015: Epub ahead of print [PMID: 27181937 DOI: 10.1111/jdi.12442]

21 **Mota J**, Vale S, Martins C, Gaya A, Moreira C, Santos R, Ribeiro JC. Influence of muscle fitness test performance on metabolic risk factors among adolescent girls. *Diabetol Metab Syndr* 2010; **2**: 42 [PMID: 20573222 DOI: 10.1186/1758-5996-2-42]

22 **Katzmarzyk PT**, Craig CL. Musculoskeletal fitness and risk of mortality. *Med Sci Sports Exerc* 2002; **34**: 740-744 [PMID: 11984288 DOI: 10.1097/00005768-200205000-00002]

23 **Noakes TD**. Implications of exercise testing for prediction of athletic performance: a contemporary perspective. *Med Sci Sports Exerc* 1988; **20**: 319-330 [PMID: 3050352 DOI: 10.1249/00005768-198808000-00001]

24 **Billat LV**. Use of blood lactate measurements for prediction of exercise performance and for control of training. Recommendations for long-distance running. *Sports Med* 1996; **22**: 157-175 [PMID: 8883213 DOI: 10.2165/00007256-199622030-00003]

25 **Houmard JA**, Craib MW, O'Brien KF, Smith LL, Israel RG, Wheeler WS. Peak running velocity, submaximal energy expenditure, VO2max, and 8 km distance running performance. *J Sports Med Phys Fitness* 1991; **31**: 345-350 [PMID: 1798303]

26 **Jones AM**. A five year physiological case study of an Olympic runner. *Br J Sports Med* 1998; **32**: 39-43 [PMID: 9562162 DOI: 10.1136/bjsm.32.1.39]

27 **Tanaka K**, Watanabe H, Konishi Y, Mitsuzono R, Sumida S, Tanaka S, Fukuda T, Nakadomo F. Longitudinal associations between anaerobic threshold and distance running performance. *Eur J Appl Physiol Occup Physiol* 1986; **55**: 248-252 [PMID: 3732252 DOI: 10.1007/BF02343795]

28 **Bragada JA**, Santos PJ, Maia JA, Colaço PJ, Lopes VP, Barbosa TM. Longitudinal Study in 3,000 m Male Runners: Relationship between Performance and Selected Physiological Parameters. *J Sports Sci Med* 2010; **9**: 439-444 [PMID: 24149638]

29 **Eisenmann JC**, Wickel EE, Welk GJ, Blair SN. Relationship between adolescent fitness and fatness and cardiovascular disease risk factors in adulthood: the Aerobics Center Longitudinal Study (ACLS). *Am Heart J* 2005; **149**: 46-53 [PMID: 15660033 DOI: 10.1016/j.ahj.2004.07.016]

30 **Strate LL**, Liu YL, Aldoori WH, Giovannucci EL. Physical activity decreases diverticular complications. *Am J Gastroenterol* 2009; **104**: 1221-1230 [PMID: 19367267 DOI: 10.1038/ajg.2009.121]

31 **Williams PT**. Prospective epidemiological cohort study of reduced risk for incident cataract with vigorous physical activity and cardiorespiratory fitness during a 7-year follow-up. *Invest Ophthalmol Vis Sci* 2009; **50**: 95-100 [PMID: 18408175 DOI: 10.1167/iovs.08-1797]

32 **Williams PT**. Reduction in incident stroke risk with vigorous physical activity: evidence from 7.7-year follow-up of the national runners' health study. *Stroke* 2009; **40**: 1921-1923 [PMID: 19299640 DOI: 10.1161/STROKEAHA.108.535427]

33 **Williams PT**. A cohort study of incident hypertension in relation to changes in vigorous physical activity in men and women. *J Hypertens* 2008; **26**: 1085-1093 [PMID: 18475145 DOI: 10.1097/HJH.0b013e3282fb81dc]

34 **Williams PT**. Changes in vigorous physical activity and incident diabetes in male runners. *Diabetes Care* 2007; **30**: 2838-2842 [PMID: 17704345 DOI: 10.2337/dc07-1189]

35 **Williams PT**. Interactive effects of exercise, alcohol, and vegetarian diet on coronary artery disease risk factors in 9242 runners: the National Runners' Health Study. *Am J Clin Nutr* 1997; **66**: 1197-1206 [PMID: 9356539]

36 **Yankelson L**, Sadeh B, Gershovitz L, Werthein J, Heller K, Halpern P, Halkin A, Adler A, Steinvil A, Viskin S. Life-threatening events during endurance sports: is heat stroke more prevalent than arrhythmic death? *J Am Coll Cardiol* 2014; **64**: 463-469 [PMID: 25082579 DOI: 10.1016/j.jacc.2014.05.025]

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**Table 1 Baseline demographics, hemodynamics, medical and family history, and habit of exercise of men and women in the cardiorespiratory fitness and hospitalization events in armed forces study**

|  |  |  |
| --- | --- | --- |
|  | **Men**  **(*n* = 3669)** | **Women**  **(*n* = 411)** |
| **Age (yr)** | 29.3 ± 5.9 | 28.1 ± 6.5 |
| **Specialty (%)** |  |  |
| Air force | 28.0 | 23.6 |
| Army | 50.5 | 61.6 |
| Navy | 21.5 | 14.8 |
| **Height (cm)** | 171.8 ± 5.8 | 160.5 ± 4.4 |
| **Weight (kg)** | 73.5 ± 10.2 | 58.1 ± 8.1 |
| **Body mass index (kg/m2)** | 24.9 ± 3.1 | 22.5 ± 2.9 |
| **Waist circumference (cm)** | 83.4 ± 8.0 | 73.3 ± 7.4 |
| **Pulse rate (times/minute)** | 72.2 ± 10.8 | 75.7 ± 10.1 |
| **Systolic blood pressure (mmHg)** | 118.4 ± 13.1 | 106.5 ± 12.4 |
| **Diastolic blood pressure (mmHg)** | 70.6 ± 10.1 | 65.2 ± 9.1 |
| **Current smoking (%)** | 38.1 | 12.2 |
| **Current alcohol intake (%)** | 44.7 | 17.1 |
| **Current betel chewing (%)** | 12.0 | 1.2 |
| **Medical history (%)** |  |  |
| Hypertension | 1.5 | 0.2 |
| Symptomatic arrhythmia | 1.1 | 1.7 |
| Chronic hepatitis B | 3.4 | 1.7 |
| **Family history of cardiovascular disease within 3rd relatives (%)** | 3.4 | 4.6 |
| **Frequency of exercise (%)** |  |  |
| Never or occasionally | 19.7 | 30.5 |
| * 1. times/wk | 38.2 | 42.9 |
| Over 3-5 times/wk | 42.2 | 26.6 |
| **Cardiopulmonary distress symptoms related to exercise (%)** | 8.9 | 15.4 |

Data were presented as the mean ± SD and percentage (%).

**Table 2 Baseline laboratory and electrocardiographic findings of men and women in the cardiorespiratory fitness and hospitalization events in armed forces study**

|  |  |  |
| --- | --- | --- |
|  | **Men**  **(*n* = 3669)** | **Women**  **(*n* = 411)** |
| **Blood routine** |  |  |
| Hemoglobin (g/dL) | 15.2 ± 1.0 | 13.0 ± 1.0 |
| Mean corpuscular volume (fl) | 85.1 ± 6.3 | 85.2 ± 6.8 |
| RBC count (106/μL) | 5.3 ± 0.5 | 4.7 ± 0.4 |
| WBC count (103/μL) | 6.8 ± 1.7 | 6.6 ± 1.7 |
| Platelet count (103/μL) | 252.9 ± 50.5 | 274.5 ± 53.1 |
| **Blood biochemistry** |  |  |
| Fasting glucose (mg/dL) | 93.6 ± 13.4 | 89.1 ± 7.5 |
| Total cholesterol (mg/dL) | 174.4 ± 34.0 | 167.4 ± 29.1 |
| LDL-cholesterol (mg/dL) | 106.0 ± 29.7 | 93.5 ± 25.3 |
| HDL-cholesterol (mg/dL) | 47.9 ± 9.8 | 56.9 ± 11.0 |
| Triglycerides (mg/dL) | 115.1 ± 100.3 | 77.7 ± 38.9 |
| BUN (mg/dL) | 12.9 ± 2.8 | 10.7 ± 2.4 |
| Creatinine (mg/dL) | 1.0 ± 0.1 | 0.7 ± 0.1 |
| eGFR (mL/min per 1.73 m2) | 99.8 ± 14.2 | 109.4 ± 18.4 |
| Uric acid (mg/dL) | 6.7 ± 1.3 | 4.7 ± 0.9 |
| AST (U/L) | 20.7 ± 8.9 | 16.2 ± 5.2 |
| ALT (U/L) | 23.1 ± 17.7 | 12.5 ± 7.3 |
| **Urinalysis (%)** |  |  |
| Protein > 1+ | 10.3 | 10.5 |
| RBC > 1+ | 5.3 | 17.4 |
| Occult blood > 1+ | 3.4 | 17.8 |
| WBC > 6-10 | 2.1 | 11.2 |
| Bacteria > 1+ | 2.6 | 22.4 |
| **12-lead Electrocardiography (%)** |  |  |
| LVH/RVH/IVCD | 17.3/1.0/0.2 | 2.0/0.2/0 |
| LAE/RAE | 0.2/0.2 | 0.2/0 |
| ICRBBB/CRBBB | 3.9/0.5 | 0.73/0 |
| LAFB/LPFB | 0.7/0.2 | 0/0 |
| 1st degree atrioventricular block | 3.8 | 3.4 |
| PACs/PVCs | 0.4/0.6 | 0.2/0.2 |

Data were presented as the mean ± SD and percentage (%). ALT: Alanine transaminase; AST: Aspartate transaminase; BUN: Blood urea nitrogen; CHIEF: Cardiopulmonary fitness and hospitalization events in armed forces; CRBBB: Complete right bundle branch block; eGFR: Estimated glomerular filtration rate; HDL: High-density lipoprotein; ICRBBB: Incomplete complete right bundle branch block; IVCD: Intraventricular conduction delay; LAE: Left atrial enlargement; LAFB: Left anterior fascicular block; LPFB: Left posterior fascicular block; LDL: Low-density lipoprotein; LVH: Left ventricular ventricular hypertrophy; PACs: Premature atrial contractures; PVCs: Premature ventricular contractures; RAE: Right atrial enlargement; RBC: Red blood cell; RVH: Right ventricular hypertrophy; WBC: White blood cell.

**Table 3 Brief symptom rating score of men and women in the cardiorespiratory fitness and hospitalization events in armed forces study**

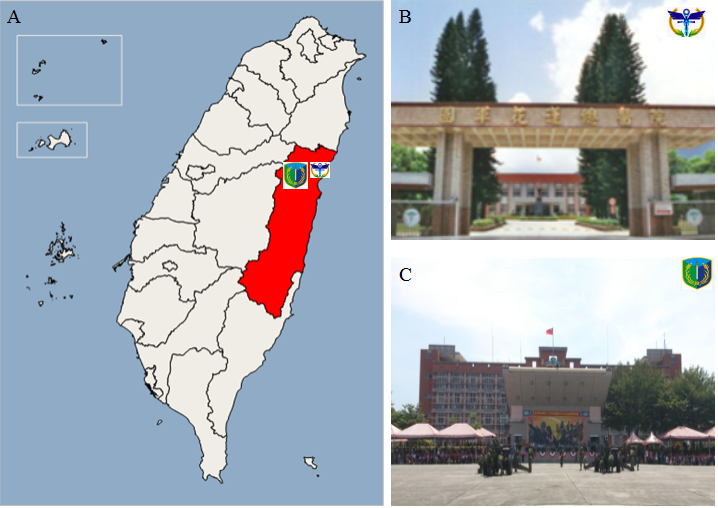
|  |  |  |
| --- | --- | --- |
|  | **Men**  **(*n* = 3669)** | **Women**  **(*n* = 411)** |
| **Anxiety (%)** |  |  |
| None (0) | 69.52 | 59.72 |
| Mild (1) | 25.1 | 32.2 |
| Moderate (2) | 4.7 | 7.6 |
| Severe (3) | 0.4 | 0.2 |
| Extremely severe (4) | 0.3 | 0.2 |
| **Depression (%)** |  |  |
| None (0) | 72.0 | 63.2 |
| Mild (1) | 23.0 | 28.1 |
| Moderate (2) | 4.1 | 7.8 |
| Severe (3) | 0.7 | 0.7 |
| Extremely severe (4) | 0.3 | 0.2 |
| **Hostility (%)** |  |  |
| None (0) | 65.7 | 55.1 |
| Mild (1) | 27.3 | 33.9 |
| Moderate (2) | 5.8 | 9.8 |
| Severe (3) | 0.9 | 0.7 |
| Extremely severe (4) | 0.3 | 0.5 |
| **Insomnia (%)** |  |  |
| None (0) | 63.5 | 58.8 |
| Mild (1) | 28.0 | 29.5 |
| Moderate (2) | 6,7 | 9.5 |
| Severe (3) | 1.4 | 1.2 |
| Extremely severe (4) | 0.4 | 1.0 |
| **Interpersonal hypersensitivity: Inferiority (%)** |  |  |
| None (0) | 79.3 | 73,2 |
| Mild (1) | 16.5 | 21.0 |
| Moderate (2) | 4.0 | 5.0 |
| Severe (3) | 0.5 | 0.2 |
| Extremely severe (4) | 0.2 | 1.0 |
| **Suicide ideation (%)** |  |  |
| None (0) | 96.4 | 95.0 |
| Mild (1) | 2.4 | 3.7 |
| Moderate (2) | 0.6 | 1.5 |
| Severe (3) | 0.4 | 0.0 |
| Extremely severe (4) | 0.3 | 0.0 |

Data were presented as percentage (%).

**Table 4 Exercise performances of men and women in the cardiorespiratory fitness and hospitalization events in armed forces study**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Men** | | **Women** | |
|  | *n* | Performance | *n* | Performance |
| **2-min sit-up** | 3651 | 47.5 ± 8.2 | 408 | 37.7 ± 8.1 |
| **2-min push-up** | 3641 | 49.1 ± 11.7 | 391 | 33.9 ± 10.6 |
| **3000-m non-weight bearing running (s)** | 3296 | 859.9 ± 72.7 | 320 | 1007.1 ± 76.9 |

Data were presented as the mean ± SD.

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**Figure 1 Geographic institutions of the cardiorespiratory fitness and hospitalization events in armed forces study performed.** (A) The map of Hualien County in Taiwan is highlighted in red, and the symbols represent (B) the Hualien-Armed Forces General Hospital and (C) the Military Physical Training and Testing Center in the Army HuaDong Defense Command.



**Figure 2 Illustrations of standardized procedure for push-up and sit-up tests in the cardiorespiratory fitness and hospitalization events in armed forces study, respectively.** A: A participant prepared for the push-up test surrounded by four flared sensors and a computerized monitor was ahead of him. A supervisor squatted aside by him to watch for all his procedure; B: A participant prepared for the sit-up test with two touch sensors were bound on both thighs and a computerized monitor was opposite to him. A supervisor stood aside by him to watch for all his procedure.



**Figure 3 Flow diagram to select the eligible cardiorespiratory fitness and hospitalization events in armed forces cohort during 2014.**