

Psychology

The leading aim of our Department is to explore the psychophysiological mechanisms underlying human stress reaction, by adopting the current methodology of cardiovascular psychophysiology. Our basic research, especially on developing the non-invasive new measures of cardiovascular hemodynamics, autonomic regulation and vascular health, has stimulated application studies orienting to the human mind-body interaction and health promotion.

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1. Assessment of psychosocial chronic stress indexed by a simple measure of small artery stiffness

Stiffening of the small artery is likely to be the earliest sign of arteriosclerosis. However, there is no adequate method for directly assessing a small arterial stiffness. Finger arterial elasticity index (FEI) was defined as the parameter n that denotes the curvilinearity of an exponential model of arterial volume (V_a) to blood pressure (P) relationship [$V_a = a - b \exp(-nP)$]. Although FEI can be calculated accurately from a compliance from the finger photoplethysmogram (PG) whilst occluding the finger, finger arterial stiffness (FSI; Tanaka et al., 2011) is conveniently estimated and devised by utilizing normalized pulse volume (NPV) instead of the compliance (Tanaka & Sawada 2012: Patent No. 5039123).

Allostatic load (AL) describes how chronic psychosocial stress relates to health outcomes. Stiffening of the small artery as the earliest sign of arteriosclerosis may be a useful pre-clinical criterion of AL. FSI was measured in two different age groups of Japanese healthy young men: those over 23 (mean age, 25.5 ± 3.3 ; $n = 78$) and those under 22 (mean age, 20.0 ± 1.3 ; $n = 292$) years of age. Summary index of AL (ALI), which was defined by the mean of standard scores for 10 measures: body mass index, body fat, systolic and diastolic blood pressure, high-density lipoprotein cholesterol (HDL), total cholesterol/HDL ratio, triglycerides, hemoglobin A1c, homeostasis model assessment-insulin resistance, and C-reactive protein. We compared the association of ALI with lifestyle and stress-related psychosocial factors between the groups. Results demonstrated the superiority of FSI to CAVI (large artery stiffness), as an indicator of the early sign of arteriosclerosis mediated by chronic psychosocial stress. ALI and FSI were progressively associated with advancing age in the asymptomatic young men. ALI was differentially associated with psychosocial and lifestyle factors in the two age groups via

different kinds of stress-coping strategies. These findings suggest that FSI is likely to be useful for investigating the comprehensive and progressive nature of the early stage of chronic stress-arteriosclerosis linkage (1, 2).

2. Finger arterial flow-mediated compliance response (FCR) as a simple measure of small artery endothelial function

FCR is derived from compliance index (Tanaka et al. 2002) during reactive hyperemia (RH-FCR test), which can evaluate peripheral vascular endothelial function (Tanaka 2013: Patent No. 6203737). The consistency of FCR with Framingham Reactive Hyperemia Index (FRHI) using a medical standard test of pulse amplitude tonometry (Endo-PAT2000, Itamar Medical Co.) has been examined in 115 diabetes and/or hypertension patients (77 men and 38 women, 60 ± 11 years of age). The structural equation modeling procedure showed a significant causal relationship between FRHI and hyperemic changes in hemodynamics; there was an increase in arterial blood volume and FCR arterial compliance and a decrease in diastolic blood pressure (GFI= .973, AGFI= .899, NFI = .959, CFI= .981, RMSEA= .088) (3).

3. Association between psychosocial stress, personality and lifestyles to the small artery endothelial function

We examined the relationship of FCR with psychosocial factors in Japanese youth. Healthy young students ($n=78$; 22 men and 56 women) were tested by RH-FCR with a number of personality inventories and lifestyle questionnaire. Eating habit was assessed by eating behavior scale for Japanese young adults that we had developed (4, 5). Increase in FCR of the RH-ADA showed significant partial correlations with the Trait anger, Anger expression-In (anger expression inwardly) of State-Trait Anger Expression Inventory (STAXI2) and Sense of Coherence ($r = -.56, -.54, .45$ in men and $r = -.41, -.36, .30$ in women, respectively), adjusting age and pre-hyperemia baseline

compliance. For sleep quality and disturbances over a recent 1-month, FCR showed significant partial correlations only with the daytime dysfunction of the Pittsburgh Sleep Quality Index ($r = -.37$). In conclusion, RH-FCR shows potential as a simple and easy to use assessment of finger arterial endothelial function, and FCR seems to be adversely mediated by chronically enhanced sympathetic activity associated with psychosocial factors in Japanese youth (6-8).

Recently, we have improved the RH-FCR to RH-NPV test applying a new patent (Tanaka 2017: Application No. PCT/JP2017/010414). RH-NPV index was reconfirmed to be associated with Anger expression-In, as well as with Buss-Perry Aggression Scale in another sample of healthy young women ($n=40$, age 19.7 ± 1.7).

4. Development of a new device for measuring baroreflex-based parasympathetic and vascular sympathetic autonomic activities using NPV

NPV described above is expressed as PGac/PGdc. Here, PGac and PGdc are the alternate and direct current components of the photo-plethysmogram (PG), respectively. Using a theoretical pressure-volume curve, it was confirmed that NPV was directly proportional to the pulsating component of the arterial blood volume. Notably, as a stress marker, NPV was predicted to be more sensitive than the other two PG indices, when exploring the effects of increases in vascular resistance and elevations of blood pressure on these PG indices during rest and mental stress (9). Based on the NPV measurement, new devices have been developed as followed;

When blood pressure excessively rises or falls, brain plays for keeping it in a normal range. This mechanism is so-called baroreflex. A new device can measure the neurogenic baroreflex sensitivity (parasympathetic activity) by calculating the slope of a regression line representing the correlation between the NPV and the pulse interval in a baroreflex series (Kato 2017: Patent No. 6297539), and additionally vascular autonomic activity by calculating the deviation of NPV in that series (Kato 2018: Patent application No. PCT/JP2018/013525).

5. Biological recovery function after mental stress

Biological recovery function after mental stress has to date been proposed for the mediation process of stress into physical health. We continuously measured blood pressure of 142 young men before, during, and after mental stress tasks. Recovery function was calculated by our newly developed index (MRR). Depression (the Center for Epidemiologic Studies Depression Scale) and optimism (the revised-Life Orientation Test) were evaluated in advance. Moderation analysis was done using Johnson-Neyman technique. A significant association was found between the MRR and depression score below the 12.3 score of dispositional optimism. The MRR offers an advantage independent of the effect of the initial level of stress reactivity. The biological recovery function after stress is likely to be adequately associated with negative affective state at the low level of optimism (10).

List of Main Publications from 2014 to 2018

- 1) Tanaka G, Horiguchi M, Okamura H, Kato Y, Tsuda A. Association between chronic psychosocial stress and the finger arterial stiffness mediated by allostatic load in healthy young men. In Evans G. (Ed.), *Chronic stress and health*. (2017) pp.1-32. Nova Science Publishers.
- 2) Tanaka G, Kato Y, Okamura H, Yajima J, Tsuda A. Chronic psychosocial stress mediators to the vascular health in different age groups of healthy young men. The 5th International Conference of Indigenous and Cultural Psychology, 10-11 January (2014), Surakarta, Indonesia.
- 3) Tanaka G, Furumoto T, Kato Y. Hemodynamic correlates of the finger arterial hyperemia as a measure of endothelial function. 13th International Congress of Behavioral Medicine. Suppl p37. 20-23 August (2014), Groningen, Netherlands.
- 4) Horiguchi M, Tanaka G., Ogasawara H, Maruyama R. Gender-based relationship between eating behavior and sense of coherence in Japanese young adults. *Soc Behav Personal*, (2016). 44(1), 45–58.
- 5) Horiguchi M, Tanaka G, Ogasawara H, Maruyama R. Validation and gender-based comparison of the Eating Behavior Scale for Japanese young adults. *Psychology*, (2014) 5, 2173-2179.
- 6) Tanaka G, Mihara K, Okamura H, Tsuda, A. A novel technology to measure finger arterial endothelial function and its relationship with anger, anger expression and sense of coherence in Japanese healthy youth. *International Journal of Psychology*, 51 (Supplement S1), 934. 31st International Congress of Psychology, 24-29 July (2016), Yokohama, Japan.
- 7) Tanaka G., Mihara K, Okamura H, Horiguchi M, Tsuda A. Differential relationship of sleep disturbances and daytime dysfunction to the finger arterial endothelial function and arterial elasticity in healthy Japanese youth. The 6th Asian Congress of Health Psychology, 23–24 July (2016), Yokohama, Japan.
- 8) Tanaka G, Mihara K, Okamura H, Tsuda A. A novel technology to measure vascular response affected by psychosocial and biological stress. The 7th International Conference of Indigenous and Cultural Psychology, 25-27 August (2015), Bandung, Indonesia.
- 9) Sawada Y, Kato Y. Hemodynamics of the Finger Photo-plethysmogram: Examinations with Emphasis on Normalized Pulse Volume. *Jpn J Physiol Psychol & Psychophysiol* (2014), 32:157–172 (in Japanese).
- 10) Kato Y, Michizuka M, Tanaka G., Sawada Y. Biological recovery function after stress is related with the interaction of negative and positive affect. 13th International Congress of Behavioral Medicine. Suppl p34. 20-23 August (2014), Groningen, Netherlands.