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# Long-term head tilt exercises significantly enhance heart rate variability: A pilot study

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*Received 9 January 2026*; *Accepted 20 January 2026*; *Published online 5 February 2026*; *Published 1 June 2027*


**Abstract**
Heart rate variability (HRV) is one of the most important indicators for heart and overall health. In present study, the effect of long-term head tilt excises on HRV is experimented. The results demonstrated that heart rate variability can be enhanced through long-term head tilt excises. In addition, HRV decreases as the increase of pulse wave velocity. Pulse pressure increases as the increase of pulse wave velocity. Diastolic pressure decreases as the increase of pulse wave velocity. The physiological mechanism by which long-term head tilt exercises enhance HRV is that the exercises reduce sympathetic nervous activity and increase parasympathetic nervous activity by squeezing the back of the neck. Long-term head tilt exercises can help maintain sympathetic activity at a lower level while keeping parasympathetic activity at a higher level, thereby enhancing HRV.

**Keywords** head tilt excises; heart rate variability (HRV); pulse wave velocity (PWV); pulse pressure (PP).

**Network Pharmacology**
**ISSN 2415-1084**
**URL: http://www.iaees.org/publications/journals/np/online-version.asp**
**RSS: http://www.iaees.org/publications/journals/np/rss.xml**
**E-mail: networkpharmacology@iaees.org**
**Editor-in-Chief: WenJun Zhang**
**Publisher: International Academy of Ecology and Environmental Sciences**

## 1 Introduction

Heart rate variability (HRV) refers to the natural fluctuations in the time intervals between consecutive heartbeats (RR intervals), representing the dynamic balance between sympathetic and parasympathetic branches of the autonomic nervous system (Shaffer & Ginsberg, 2017; Task Force, 1996). High HRV generally reflects good autonomic regulation and cardiovascular adaptability, whereas low HRV is associated with increased risk for cardiovascular disease, stress, and inflammatory states. HRV is influenced by multiple factors including age, physical activity, psychological stress, sleep quality, disease status, and pharmacological interventions (Mancia et al., 2023).

Pulse wave velocity (PWV) is a key measure of arterial stiffness, obtained by measuring the speed at which the arterial pulse propagates from the heart to peripheral sites (Laurent et al., 2001; Nichols et al., 2011). Increased PWV reflects reduced arterial compliance, and is strongly linked to hypertension, atherosclerosis, and enhanced risk of cardiovascular events (Vlachopoulos et al., 2010; Townsend et al., 2015). PWV is affected by aging, blood pressure levels, diabetes, and inflammation, with chronic elevated blood pressure accelerating collagen deposition and elastic fiber fragmentation in arterial walls, thereby reducing compliance.

Pulse pressure (PP) — the difference between systolic and diastolic blood pressure — serves as a simple surrogate for arterial stiffness and cardiac ejection dynamics. Elevated PP is often closely related to higher PWV, as stiff arteries increase systolic pressure and reduce diastolic pressure, widening the pulse pressure (Nichols et al., 2011). Clinical studies have shown that in middle-aged and older populations, high PP is an independent predictor of myocardial infarction and stroke (Laurent et al., 2001).

Mechanistically, HRV is primarily determined by neural regulation — specifically the interactions between sympathetic and parasympathetic inputs — and modulation of the cardiac pacemaker (Task Force, 1996). PWV and PP mainly reflect structural and functional changes in arteries and hemodynamic forces (Nichols et al., 2011). There are important interconnections: chronic sympathetic overactivity can raise blood pressure and promote arterial remodeling, thereby increasing PWV and PP; conversely, elevated arterial stiffness and PP can reduce baroreceptor sensitivity, potentially decreasing HRV (Vlachopoulos et al., 2010).

Despite advancements in measurement techniques and clinical applications, gaps remain. HRV can be heavily influenced by external factors, so its clinical interpretation must be integrated with other physiological and psychological metrics (Shaffer & Ginsberg, 2017). PWV measurements vary depending on methodology and pathway selection, making cross-device and cross-study comparisons difficult (Townsend et al., 2015). PP, while simple to measure, lacks universally agreed risk thresholds for different populations.

Future research should focus on developing composite risk scores that combine HRV, PWV, and PP for better early prediction of cardiovascular events (Mancia et al., 2023). Wearable technology could enable real-time monitoring of these indices, coupled with AI analytics to detect early trends in cardiovascular function (Zhang & Qi, 2025). Lifestyle interventions such as exercise, breathing training, and dietary modification should be studied for their potential to simultaneously improve HRV, PWV, and PP, offering a holistic approach to cardiovascular health.

Health status can be improved by physical excises. In my earlier study, I have proved that head tilt excise can decrease heart rate by reducing sympathetic nervous activity and increasing parasympathetic nervous activity. Heart rate variability is one of the most important indicators for heart and overall health. Thus in present study the effect of long-term head tilt excises on HRV is experimented, aiming to provide an effective way for improvement of HRV and overall health.

## 2 Material and Methods

A volunteer is employed in present experiment. The health status and other conditions of the volunteer remain constant and stable during the experiment.

In present study, head tilt exercise refers to standing straight, tilting the head backward to the right rear to squeeze the back of the neck and gazing directly at the ceiling for 20 seconds, then tilting the head directly backward to squeeze the back of the neck and gazing at the ceiling for 20 seconds (Fig. 1), followed by tilting the head backward to the left rear to squeeze the back of the neck and gazing directly at the ceiling for 20 seconds. This procedure is repeated for 20 minutes.

Measure systolic blood pressure, diastolic blood pressure, heart rate variability (HRV: RMSSD, Root Mean Square of Successive Differences), and pulse wave velocity (PWV) using HUAWEI WATCH D2-528 (Fig. 2) and Huawei Innovation Research (华为创新研究) app on Huawei smartphone.

Repeat the excise five times and the measurement four times (occasionally three times etc.) each day. The experiment is conducted for 45 days.

**Fig. 1** Tilting the head directly backward and gazing at the ceiling for 20 seconds (Zhang and Qi, 2025).


(a) (b)

**Fig. 2** HUAWEI WATCH D2-528 (a) and Huawei Innovation Research (华为创新研究) app (b).

Linear regression, and effect size measure, etc., are used in the analysis of the experimental results (Zhang, 2022, 2023; Zhang and Qi, 2024, 2025).

## 3 Results and Analyses

### 3.1 Effect of long-term head tilt excises on heart rate variability (HRV)

The regressional relationship between heart rate variability (HRV; RMSSD; milliseconds) and time (days) is fitted as the following (Fig. 3):

$y$=47.8281+0.0793$x$
$p$=0.0180, $F$=5.6545, $n$=344
Cohen' $f$=0.1282

where $y$: heart rate variability (HRV: RMSSD; milliseconds), $x$: time (days).

It can be concluded that heart rate variability will be enhanced through head tilt excises as time, although heart rate variability is influenced by so many factors as fatigue, insomnia, stress, etc.

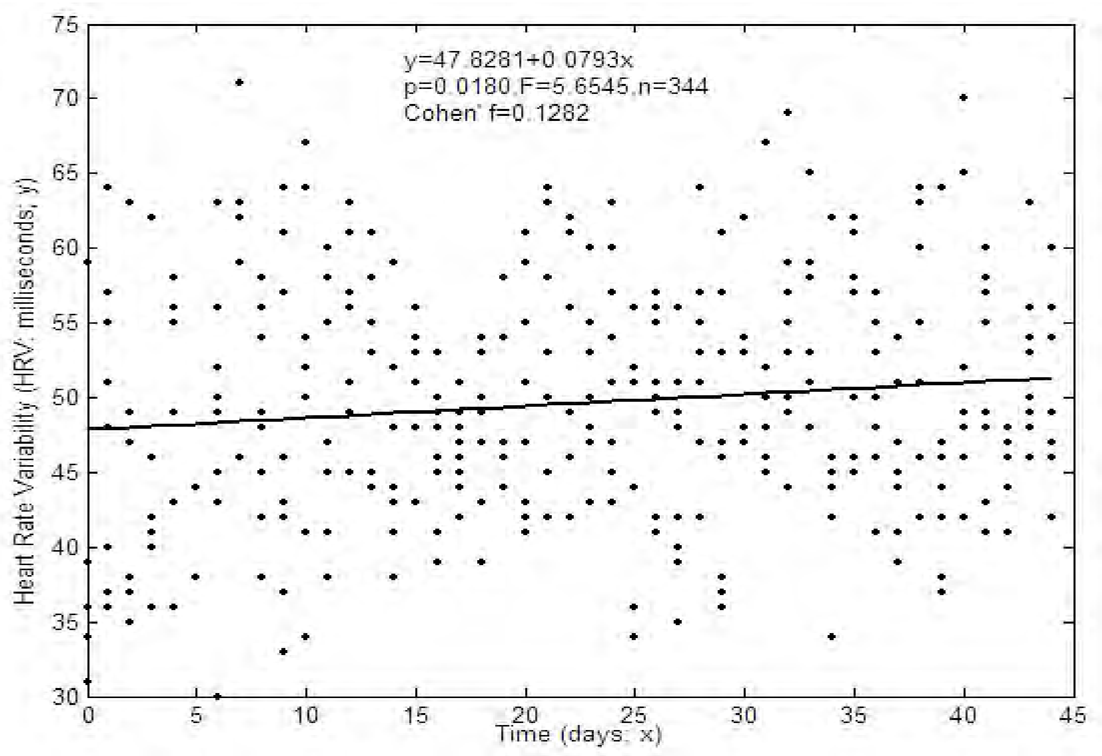


**Fig.3** Linear regression between heart rate variability (HRV; RMSSD; milliseconds) and time (days).

## 3.2 Other relationships

3.2.1 HRV-Pulse Wave Velocity (PWV)

The regressional relationship between heart rate variability (HRV; RMSSD; milliseconds) and pulse wave velocity (PWV; m/s) is fitted as the following (Fig. 4):

$y$=63.6999-1.6156$x$

$p$=0.3213, $F$=0.9896, $n$=172

Cohen' $f$=0.0755

where $y$: heart rate variability (HRV: RMSSD; milliseconds), $x$: pulse wave velocity (PWV; m/s).

It is obvious that heart rate variability decreases as the increase of pulse wave velocity. It is speculated that increased arterial stiffness increases the burden on the heart, leading to a decrease in HRV.

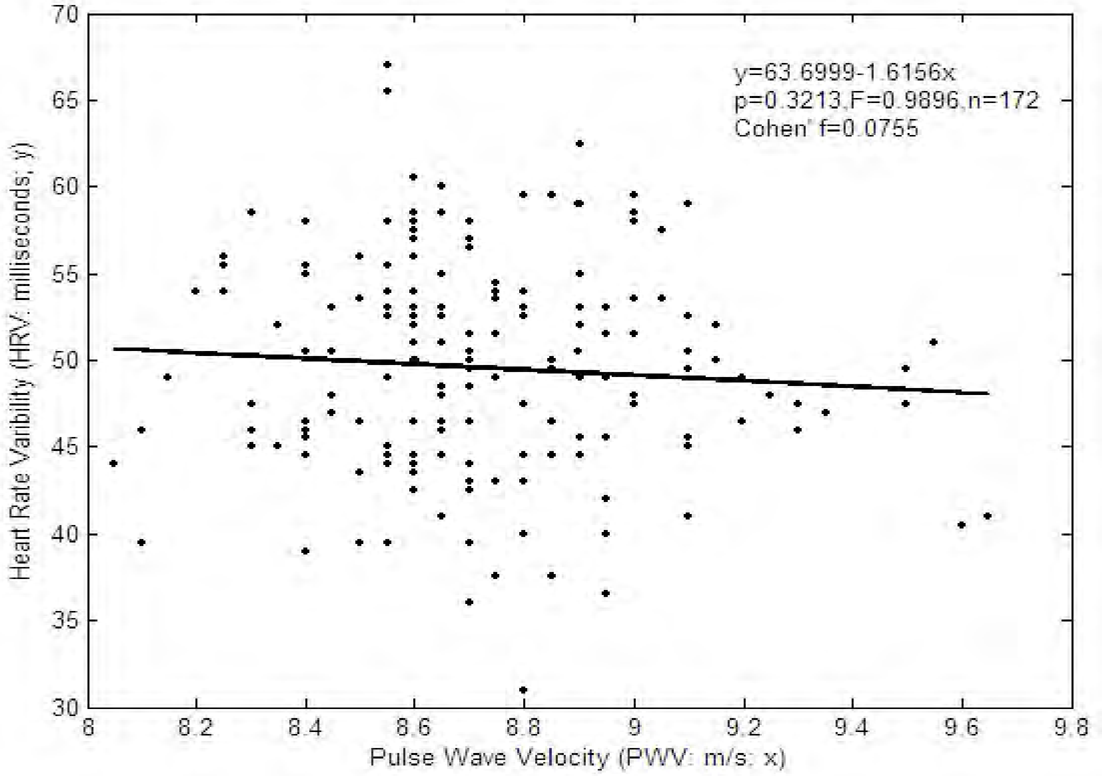


**Fig.4** Linear regression between heart rate variability (HRV: RMSSD; milliseconds) and pulse wave velocity (PWV; m/s).

3.2.2 Pulse Pressure (PP)-Pulse Wave Velocity (PWV)

The regressional relationship between pulse pressure (PP: systolic pressure-diastolic pressure; mmHg) and pulse wave velocity (PWV; m/s) is fitted as the following (Fig. 5):

$y$=32.8373+2.6143$x$
$p$=0.0732, $F$=3.2488, $n$=172
Cohen' $f$=0.1374

where $y$: pulse pressure (PP: systolic pressure-diastolic pressure; mmHg), $x$: pulse wave velocity (PWV; m/s).

Exchange the $x$ and $y$, we have

$y$=8.3273+0.0072$x$
$p$=0.0732, $F$=3.2488, $n$=172
Cohen' $f$=0.1374
where $y$: pulse wave velocity (PWV; m/s), $x$: pulse pressure (PP: systolic pressure-diastolic pressure; mmHg).

Pulse pressure is generally recognized as the ideal indicator for arterial arterial stiffness. This is basically confirmed by the results above: The greater the arterial stiffness, the higher the pulse pressure; conversely, the higher the pulse pressure, the greater the arterial arterial stiffness. On the other hand, arterial arterial stiffness cannot fully explain pulse pressure. Pulse pressure is also affected by other factors. Conversely, pulse pressure cannot be 100% representative of arterial stiffness.

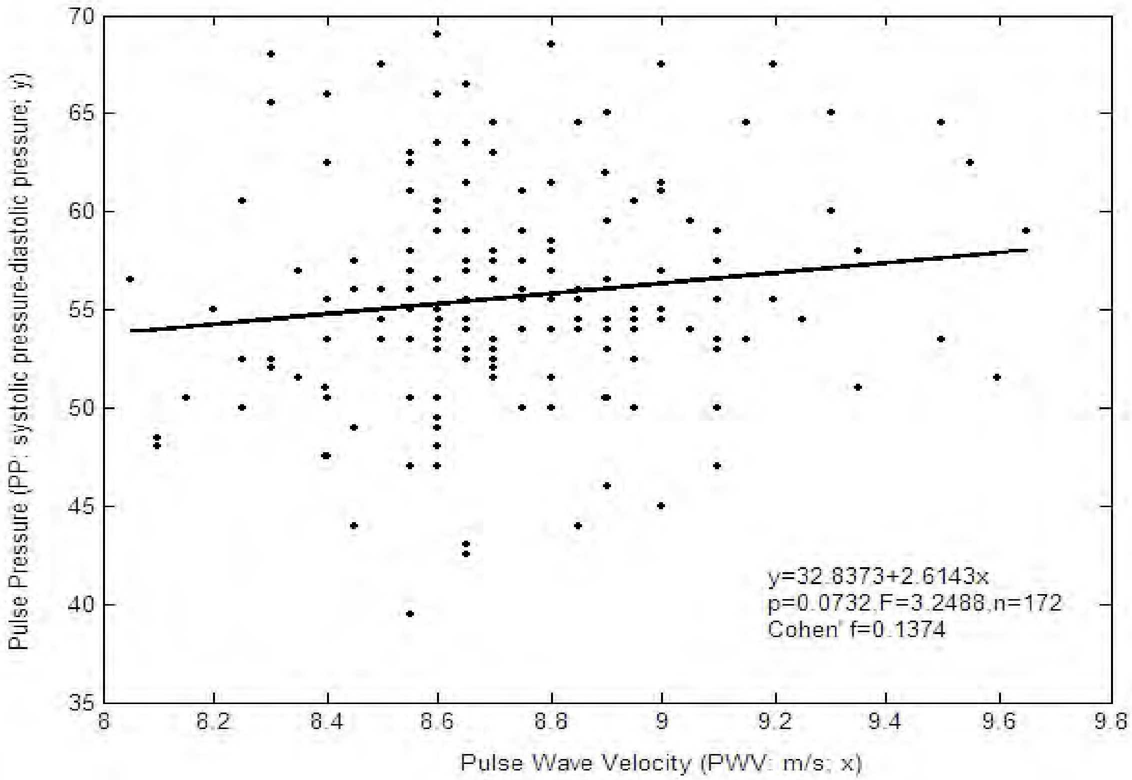


**Fig.5** Linear regression between pulse pressure (PP: systolic pressure-diastolic pressure; mmHg) and pulse wave velocity (PWV; m/s).

3.2.3 Diastolic Blood Pressure (DBP)-Pulse Wave Velocity (PWV)

The regressional relationship between diastolic pressure (mmHg) and pulse wave velocity (PWV; m/s) is fitted as the following:

$y$=68.0901-0.1469$x$

$p$=0.7923, $F$=0.0695, $n$=344

Cohen' $f$=0.0142

where $y$: diastolic pressure (mmHg), $x$: pulse wave velocity (PWV; m/s).

It demonstrates that diastolic pressure declines as the increase of arterial stiffness, which coincides with the known mechanism. However, diastolic pressure is mostly determined by other factors.

The above results also indirectly prove the rationality of the data and the credibility of long-term head tilt excises in improving HRV.

## 4 Discussion

### 4.1 Theoretical basis and physiological mechanism for enhancing HRV by long-term head tilt excises

HRV depends primarily on genetic factors, age, recent health status, and variability factors. The long-term head tilt excises focus on the improvement of recent health status.

The physiological mechanism by which long-term head tilt exercises enhance HRV is that such exercises reduce sympathetic nervous activity and increase parasympathetic nervous activity by squeezing the back of the neck (Zhang and Qi, 2025). Over time, consistently performing these exercises can help maintain sympathetic activity at a lower level while keeping parasympathetic activity at a higher level, thereby enhancing HRV.

**4.2 Main benefits of enhancing parasympathetic activity**

The parasympathetic nervous system, in contrast to the "fight or flight" sympathetic nervous system, is responsible for "rest and digestion" (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). Enhancing parasympathetic activity — i.e., allowing the body to more effectively enter a state of "rest and repair" — has comprehensive and far-reaching benefits for physical and mental health (Shaffer & Ginsberg, 2017). The main benefits of enhancing parasympathetic activity can be divided into physiological and psychological aspects:

(1) Physiological Health

Promoting Deep Relaxation and Recovery

Lowering Heart Rate and Blood Pressure: Parasympathetic activation counteracts the cardiovascular burden of stress and reduces cardiac load (Mancia et al., 2023; Zhang & Qi, 2025).

Optimizing Breathing: Guiding breathing to become deeper and slower (such as diaphragmatic breathing) improves oxygen utilization efficiency and enhances heart rate variability, a marker of autonomic balance (Shaffer & Ginsberg, 2017).

Improving Digestive System Function: When the parasympathetic nervous system is activated, the body prioritizes energy and blood allocation to digestive organs, enhancing digestive juice secretion and intestinal motility to improve nutrient absorption and relieve problems such as bloating and constipation (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

Strengthening the Immune System: Chronic sympathetic dominance suppresses immune function, whereas a parasympathetic state reduces systemic inflammation and enhances immune cell activity (Shaffer & Ginsberg, 2017).

Improving Sleep Quality: Parasympathetic dominance facilitates falling asleep and entering deeper stages of restorative sleep (Shaffer & Ginsberg, 2017).

Promoting Cell Repair and Anti-Aging: In a relaxed state, energy is directed toward cellular growth, tissue repair, and detoxification, slowing aging processes (Nichols et al., 2011).

Balancing Hormones: Lowering chronic stress hormones such as cortisol helps restore hormonal balance, which benefits metabolic and reproductive health (Mancia et al., 2023).

(2) Mental Health and Cognition

Significantly Reducing Anxiety and Stress: By physiologically interrupting the stress response, parasympathetic activation alleviates tension, panic, and excessive worry (Shaffer & Ginsberg, 2017).

Improving Emotional Stability and Positive Emotions: Activation promotes the release of serotonin and acetylcholine, fostering calmness, satisfaction, and happiness (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

Enhancing Emotional Regulation: Parasympathetic dominance improves recovery from acute emotional stress, increasing resilience and emotional flexibility (Shaffer & Ginsberg, 2017).

Improving Attention and Decision-Making Ability: Reduced stress arousal enables better prefrontal cortex functioning, improving rational thinking, focus, and problem-solving (Nichols et al., 2011).

Enhancing Self-Awareness and Inner Connection: Relaxation improves interoceptive awareness — the perception of bodily signals and emotions — promoting mind-body harmony (Shaffer & Ginsberg, 2017).

**4.3 Future improvement of head tilt excise**

The head tilt excise to enhance HRV in the present study can be further modified, e.g., tilting head back to squeeze the back of the neck and look at the ceiling for 20 to 30 seconds, then looking straight ahead for a few seconds (Zhang and Qi, 2025), repeating the procedure for tens of minutes.

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