

六周全身垂直律動對年長者生活適應性的影響



Effect of 6 weeks whole-body vibration exercise on functional fitness in the elderly

研究自：

長庚大學實驗研究

簡述內容：

日常活動時，年輕人跌倒狀況比較少見，而傷害多半較輕微；但老年人由於身體肌肉關節的無力與不協調，走路或日常活動時容易平衡不佳產生跌倒，而跌倒時由於反應遲鈍，可能造成嚴重傷害，因此改善身體姿勢穩定度、肌力和平衡感是預防跌倒的重要因素，本研究採用全身垂直律動六週訓練，分別以不同頻率(8Hz、9Hz、12Hz)測試老年人站立與步行能力，證實可以改善老年人的姿勢穩定度、增加步行距離和增強平衡能力，並且對於下降收縮壓與舒張壓也獲得改善，進而得以改善跌倒與降低血管老化及其併發症的風險發生，並提升後續生活品質。

Effect of 6 weeks whole-body vibration exercise on functional fitness in the elderly

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Introduction: Impairment of muscle strength and dynamic balance, and walking ability have been found to be important risk factors for fall. These parameters are known to become impaired with aging. Whole body vibration (WBV) training is being used as a new method for improving strength, power and body balance for the young people and athletes. However, it is not known long-term and short time training of WBV will affect the elderly functional fitness which including lower limbs strength, cardio function and body balance.

Purpose: To determine the long-term six weeks WBV training effect on the elderly functional fitness which including three test: six meter up and go, thirty seconds chair stand and six minutes walk.

Methods: 24 healthy elderly people (only 19 people completely finished the training that were 10 males age 84.3 ± 6.7 yrs, 63.8 ± 7.6 kg, 164.8 ± 7.1 cm; 9 females age 79.7 ± 5.0 yrs, 60.6 ± 6.8 kg, 157.2 ± 6.4 cm) were volunteered to participate in this study which were six weeks WBV training. Elderly people were performed in standing position on a BodyGreen whole vertical vibratory machine (Taiwan), at an intensity of the 1st week to the 4th week: frequency set at 12 Hz, amplitude set at 3mm, exercise time was 10minutes, during the 5th week: frequency set at 9 Hz, amplitude set at 4mm, exercise time was 15minutes and during the 6th week : frequency set at 8 Hz, amplitude set at 5mm, exercise time was 15minutes, for every Monday, Wednesday and Friday morning in a week. We analyze the data before 6 weeks WBV training and after the training for using Paired Samples T-test.

Results and Conclusions: : After 6 weeks WBV exercise program, the 6 minutes walking distance, the time of six meter up and go and the times of thirty seconds chair stand were all significantly improved ($p<.05$). Thus, the present study showed the beneficial effect of the 6 weeks WBV exercise in the elderly functional fitness. This easy WBV exercise program maybe can be promoted to the community to prevent the elderly falling.

Keywords: whole body vibration, older, the elderly, functional fitness

全身律動對第二型糖尿病的控制效果



Efficiency of vibration exercise for glycemic control in type 2 diabetes patients

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簡述內容：

糖尿病的發生可能與遺傳相關，其他如肥胖、情緒壓力、懷孕、藥物、營養失調，都可能會促使糖尿病的發生，當胰島素阻抗或不敏感時會造成血糖升高，而血糖控制不佳時，可能會導致併發症的產生，包括眼睛病變、腎臟病變、心血管病變、神經病變等等，但持續規律的運動可以降低糖尿病患者的血糖。

本研究將糖尿病患者分為全身垂直律動組、力量訓練組和對照組，顯示全身垂直律動後，經由測試「口服葡萄糖耐受性測驗」和「糖化血色素」數值皆明顯降低，證實垂直律動可以作為改善第二型糖尿病患者血糖的有效工具。而律動改善血糖的作用有三個系統路徑：(1)分泌造骨細胞的骨鈣素，刺激胰島素分泌降低血糖(2)降低免疫系統的發炎反應，因此降低糖尿病的形成(3)透過刺激脂肪細胞增加脂聯素分泌，降低肥胖與糖尿病機會。

Research Paper

Efficiency of vibration exercise for glycemic control in type 2 diabetes patients

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Although it is well documented that persons suffering from diabetes type 2 profit from muscular activities, just a negligible amount of patients take advantage of physical exercises. During the last decade, vibration exercise (VE) could be established as an effective measure to prevent muscular atrophy and osteoporosis with low expenditure of overall exercise-time. Unfortunately, little is known about the metabolic effects of VE. In the present study we compared VE with the influence of strength training and a control group (flexibility training) on glycemic control in type 2 diabetes patients. Forty adult non-insulin dependent patients participated in the intervention. Fasting glucose concentration, an oral glucose tolerance test (OGTT), haemoglobin A1c (HbA1c), the isometric maximal torque of quadriceps muscles, and endurance capacity were evaluated at baseline and after 12 weeks of training with three training sessions per week. The main findings are: Fasting glucose concentrations remain unchanged after training. The area under curve and maximal glucose concentration of OGTT were reduced in the vibration and strength training group. HbA1c values tended to decrease below baseline date in the vibration training group while it increased in the two other intervention groups. These findings suggest that vibration exercise may be an effective and low time consuming tool to enhance glycemic control in type 2 diabetes patients.

Key words: diabetes, vibration exercise, strength training, HbA1c, glycemic control

1. Introduction

Since some decades it is known that beside pharmacological treatments and body weight reduction endurance related exercises are able to enhance glycemic control in type II diabetes patients [13,18,22]. More recently, strength training also became an established treatment in that world-wide spreading metabolic disease [2,3,4,9]. However, till today only a negligible amount of patients take advantage of any sport activity. There are some reasons to explain that phenomenon, one of the most important may be that nearly all patients are obese and follow a lifelong sedentary life style. Obviously, these patients can hardly be motivated for longer lasting physical activities.

Vibration exercise is a new and effective measure to prevent muscular atrophy and osteoporosis [14,15,19,21]. It is assumed that vibrations with an amplitude of 2 to 6 mm and a frequency of 20 to 30 Hz evoke muscle contractions probably induced via the monosynaptic stretch reflex [17]. Compared to traditional training regimes, VE needs significant less time and, therefore, can be expected to reach a higher compliance in previously inactive patients. Unfortunately, rare information exists about the metabolic consequences of VE. It is just known that oxygen consumption increases with body weight as well as frequency

and amplitude of VE [14]. In the present study we investigated the influence of a three month vibration-exercise period on parameters of glucose metabolism in type II diabetes patients. The results were compared to a control group (FT-group) and a group performing strength training (ST).

2. Research Design and Methods

Subjects characteristics and general experimental design

Prior to recruitment of subjects the study protocol was approved by the ethic committee of the German Sports University. Volunteers were included if they met three conditions: A diagnosed type II diabetes, not insulin depending, and not regularly involved in sport activities. All patients were under oral medication. Subjects were excluded if they suffered from retinopathy or other medical problems which did not allow for participating in vibration exercises or strength training.

Patients were encouraged to follow their habitual life style including medication throughout the whole investigation period. After verbal introduction of the study 40 subjects (24 male, 16 female) gave their written consent and participated in the study (Table 1). Subjects were randomly divided into three groups: A flexibility training group, a strength training group

and a vibration training group. They trained for 12 weeks at three days per week. All sessions were supervised and participation assessed. Training volume and intensity were stepwise increased after 6 and 9 weeks. The detailed training regimen was as follows:

Flexibility training

Each FT session consisted of eight static exercises which involved main muscles of the upper and lower body. During the initial six weeks, one set was performed with the positions kept for 20 s each. From week 7 to 9 volume was increased by one more set. During the last three weeks two sets with exercise durations of 30 s were applied. The total training duration did not exceed 15 minutes per session.

Strength training

Commercially available weight machines (Conex[®] multiform) were used for strengthening muscle groups of the upper and lower body. Eight stations were included in each session, e.g. leg extension, seated leg flexion, leg press, seated calf raise, lat pulley, horizontal chest press, butterfly, and rowing. Subjects performed dynamic contractions with intermittent relaxations after each concentric-eccentric phase in order avoid critical blood pressure responses [1]. After familiarization with the correct movements, the one repetition maximum (1RM) was established prior to the training period. During the first six weeks of training, 1 set with 12 repetitions at 70 % of 1 RM was performed. From week 7 to 9 volume was increased by an additional set. In weeks 10 to 12, 3 sets with 10 repetitions at 80 % of 1 RM were realized. About 45 minutes was needed for a training session of the last three weeks.

Vibration exercise

Subjects exercised on a horizontal swinging platform with an amplitude of 2 mm (Vibrogym Professional[®]). Vibration frequency was set to 30 Hz from weeks 1 to 9 and to 35 Hz during the last three weeks. The duration of a single exercise bout was constant throughout the training period and amounted to 30 s. A training session consisted of 8 different exercises including muscles of the whole body (Fig. 1). Subjects were encouraged to work isometrically against the swinging platform. The number of sets was identical with the strength training regimen. It took about 20 minutes to fulfill a training session of the last three weeks.

Table 1: Baseline subjects characteristics. Mean \pm SD

| Intervention group (number of subjects) | Age (years) | Weight (kp) | Height (cm) | Systolic blood pressure (mm Hg) | Diastolic blood pressure (mm Hg) |
|---|----------------|-----------------|----------------|---------------------------------|----------------------------------|
| Stretching (13) | 63,3 \pm 5,9 | 88,6 \pm 24,1 | 173 \pm 14,2 | 136 \pm 13,8 | 83 \pm 7,0 |
| Strength (13) | 62,9 \pm 7,3 | 86,5 \pm 14,7 | 172 \pm 6,7 | 142 \pm 16,2 | 87 \pm 10,4 |
| Vibration (14) | 62,2 \pm 4,0 | 83,3 \pm 13,4 | 177 \pm 7,2 | 137 \pm 15,1 | 79 \pm 7,3 |



Figure 1: Images of the eight exercises during vibration training.

Test procedure and Outcome Measures

Before and three to four days after the training period, subjects entered the laboratory after 12 h fasting and an oral glucose tolerance test was performed. Time of drug ingestion was individually kept constant prior to both tests. Micro-blood samples were taken from an ear lobe before and for 2,5 h every 30 min after administering a 75 g glucose drink (Dextro[®] O.G-T., Roche Diagnostics Ltd). Blood samples were analyzed by means of HemoCue[®] Glucose 201+ (HemoCue Ltd). HbA_{1c} levels were determined by a HPLC-System (Tosoh G7, Eurogenics) from a blood sample taken from the antecubital vein.

On separate days, maximal torque of quadriceps muscles and endurance capacity were tested. Maximal torque was detected isometrically with participants in an upright sitting posture and the hip and knee joint flexed to 90°. A force transducer (Digimax[®], Mechatronic Ltd) was used and the lever arm calculated as the distance between knee joint space and contact point of force transduction. The best of three trials of each leg were taken for further computation.

Endurance capacity was determined by an incremental cycle ergometry (Ergoline Ergoscript 2012 EL). Load was increased every 3 min for 25 w until lactic acid concentration exceeded 4 mmol/l. Heart rate (ECG leads) and lactic acid concentration (Accutrend[®] Lactate, Roche Mannheim) were measured at rest and within the last 30 s of each load.

In addition, body weight and blood pressure were measured before each training session. The mean values of the initial and last five sessions were taken for further computations.

Statistical analysis

Statistical analysis was conducted using SPSS version 12.0 for Windows. If not otherwise stated data are expressed as mean and standard deviation. The data were analyzed by analysis of variance for repeated measurements (factors: time and training form). In case that the two-factorial analysis yielded a significant result ($p < 0,05$), a Newman-Keuls test was performed as a posteriori test.

3. Results

Subjects characteristics

Body weight did not significantly change during

the 3-month intervention. A mean reduction of 1,68 kp \pm 4,57, 1,30 kp \pm 2,36, and 0,86 kp \pm 1,77 could be obtained for FT, ST, and VT, respectively. Systolic blood pressure decreased significantly ($p < 0,05$) in all intervention groups to 126 mm Hg \pm 7,4, 133 mm Hg \pm 16,4, and 123 mm Hg \pm 12,5 for FT, ST, and VT, respectively. Diastolic blood pressure did not change significantly. Three subjects decreased their oral hypoglycemic medication dosage (two persons in ST and one person in VT group). No major complications or injuries were reported from either stretching, strength, or vibration training.

Endurance performance parameters

No significant differences in endurance capacity could be detected between pre and post-training in any group. Subjects reached 4 mmol [lactate] at loads of 89 w \pm 8,2 (pre) and 86 w \pm 9,7 (post), 99 w \pm 14,8 (pre) and 95 w \pm 13,3 (post), 89 w \pm 6,2 (pre) and 92 w \pm 5,9 (post) for FT, ST, and VT, respectively. In contrast, at these loads heart rate was reduced after the training intervention in all groups (Fig. 2), which became significant for VT.

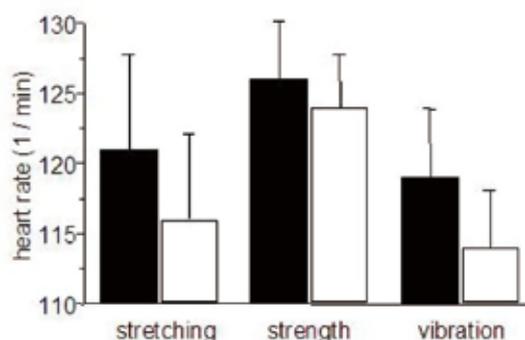


Figure 2: Mean heart rates at loads corresponding to a lactic acid concentration of 4 mmol / l. gray bars = pretraining, black bars = posttraining. mean \pm SE.

Strength

The relative maximal isometric torque of the quadriceps muscles increased after training in the ST and VT groups. A significant increase of 14 % could be obtained in subject's left leg of the ST group (Fig. 3).

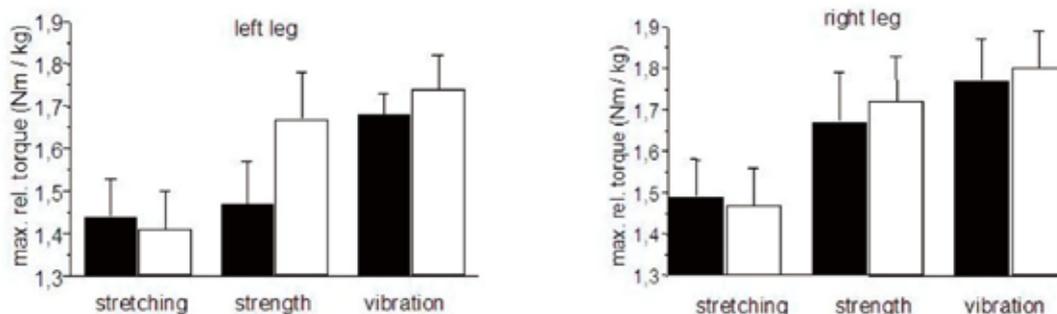


Figure 3: Relative maximal isometric torques of the quadriceps muscles. black bars = pre-training, hollow bars = post-training. mean \pm SE.

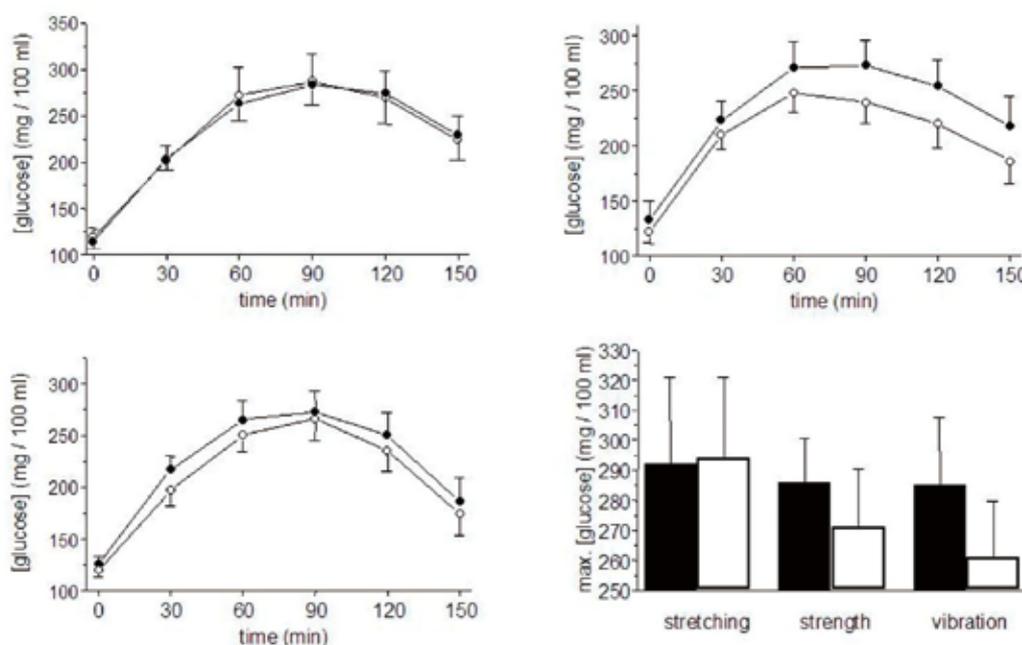


Figure 4: Glucose plasma-concentrations during OGTT before (black) and after the training period (hollow). Left top: Flexibility training group, left bottom: strength training group, right top: vibration training group. Right bottom: mean of individual maximal glucose concentrations. Mean \pm SE.

Fasting glucose concentration and OGTT

After training intervention, fasting glucose concentrations were slightly reduced in all groups (n.s., Tab. 2). Within the 150 minutes observation period of OGTT, pre- and posttraining results in the FT group were nearly identical. In both ST and VT the integrals were reduced by 5,6 % and 6,3 %, respectively ($p < 0,05$ for both groups with no significant differences between both groups). Fig. 4 shows the time courses of all three training groups as well as the mean of individual maximal glucose concentrations.

Table 2: Plasma fasting glucose concentrations before and after training intervention. Mean \pm SD

| Intervention group | Plasma [glucose] pretraining (mg / 100 ml) | Plasma [glucose] posttraining (mg / 100 ml) | Significance |
|--------------------|--|---|--------------|
| Flexibility | 120 \pm 25 | 115 \pm 22 | n.s. |
| Strength | 126 \pm 23 | 120 \pm 22 | n.s. |
| Vibration | 133 \pm 57 | 122 \pm 35 | n.s. |

HbA1c

At baseline the HbA1c amounted to 6,7 % \pm 0,26 (FT), 6,8 % \pm 0,17 (ST), and 7,3 % \pm 0,66 (VT) (Differences not significant). After training intervention a small decrease in HbA1c occurred in the VT-group (n.s.). In contrast, HbA1c values in the FT and ST group were elevated.

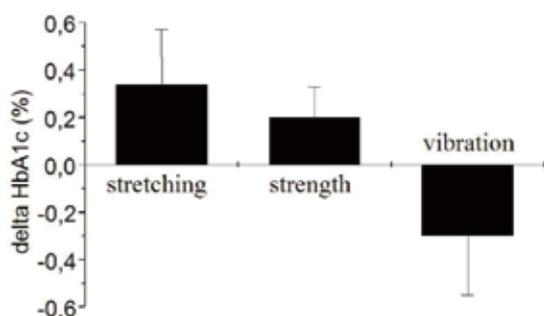


Figure 5: Net changes in HbA1c. Mean \pm SE

4. Discussion

Twelve weeks of strength training increased muscular strength and did not affect the endurance capacity while stretching and vibration exercise improved neither strength nor endurance significantly. These results on physical performance parameters reflect just in part the outcome of glycemic control parameters: As it could be expected flexibility training failed to improve glycemic control and strength training showed beneficial effects. Although the duration of VT training sessions were about half of those of the strength group, the effect on OGTT was comparable. Obviously, there is a beneficial effect of vibration-exercise on glycemic control without detectable changes in physical performance parameters. A dominant influence of body weight changes appears

unlikely since weight reduction was weakest in the VT group and strongest in the FT group. Vibrations applied on skeletal muscles activate muscle spindle receptors [10] and so enlarge the drive to alpha-motoneurons via the monosynaptic reflex [17]. Therefore, compared to exercises without vibrations it may be true that a higher number of motor units are activated. Beside some general health-related beneficial effects of exercise on skeletal muscles such as improvements of endothelial function [8] and an increased enzyme capacity of energy metabolism [13] there are two specific effects of contracting skeletal muscle cells on the ability to transport glucose into these cells: First, a regularly performed training increases the content of the glucose transporter protein GLUT-4 within the cells [9,12]. Secondly, a single bout of muscle contractions leads to a translocation of GLUT-4 to the sarcolemmal membrane, which acutely enhances glucose transport capacity [6,7,11]. Evidence of acute training effects on glycemic control rather than a chronic adaptation to training originates from the findings of Fenicchia et al. [5] and Ostergard et al. [13]. In the first study a single bout of resistance exercise was sufficient to improve glycemic control. In the endurance-training intervention of Ostergard et al. [13], no correlation between changes in maximal oxygen uptake and insulin sensitivity could be detected. The authors discussed that improvements of insulin sensitivity are dissociated from muscle mitochondrial function.

In spite of significantly reduced peak glucose concentrations and area under curve during OGTT in the post-training intervention, the 4 % reduction of HbA1c levels obtained after VT intervention failed to reach statistical significance. Moreover, in the control group (flexibility training) and the strength training group HbA1c increased by 5 % and 3 %, respectively. This finding is clearly inconsistent with the outcome of other strength-training related interventions [2,4,5]. It is well known that HbA1c reflects glycemia over the preceding two to three months [16]. The obviously missing long-lasting beneficial effect on glycemic control in the present study may be in part due to the fact that we initially used a training of low-volume load. In contrast to other studies our subjects performed only one set per session during the initial 6 weeks and three sets were applied just for the last three weeks. This slow increase in training load was utilized to enhance subject's compliance to physical activity.

Beside a dose-dependent phenomenon an alternative explanation originates from the results of Tseng et al. [20]. They reported a seasonal influence on HbA1c with higher HbA1c values during winter. This epidemiological study included more than 280.000 patients living in different climate conditions. Interestingly, the strongest summer-winter contrast appeared in the regions with an intermediate winter climate (winter temperatures between 0°C to 4.4°C). That is close to the conditions of our region. If the assumption holds that seasonal influences provoked the HbA1c increases in the FT and ST groups the 5 % HbA1c de-

crease in the vibration-exercise group may become even more meaningful.

The present paper shows, as a pilot study, that vibration exercise may be an effective measure to improve glycemic control in non insulin dependent diabetes type 2 patients. Further studies should be encouraged to optimize frequency, amplitude, and duration of vibration exercises.

Since the time to treat is far beyond traditional training forms, patients without any affinity to traditional sports activities may prefer vibration training as a part of an intended lifestyle modification.

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Conflict of interest

The authors have declared that no conflict of interest exists.

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垂直律動輔助治療慢性病的效果觀察

研究自：

四川大學公眾健康與社會發展研究所及體育科學研究所，
2016年6月17日中國慢性病管理大會報告

簡述內容：

常聽到的代謝症候群並不是指單一疾病，而是一群容易導致心血管疾病的危險因子的總稱，可以視為許多代謝疾病的前兆，而代謝症候群大多與不良生活型態、遺傳因素有關，例如飲食習慣不佳、攝取過多熱量、飲酒過量、低纖、高糖、高油脂飲食或是缺乏運動、壓力過大等等，若家族中有高血壓、糖尿病、高血脂症的患者，其代謝症候群的機率會比一般人高。

本實驗研究已經患有不同代謝疾病的患者，經由六個月全身垂直律動進行觀察，針對個別的高血糖、高血壓、高血脂、體重、體脂、BMI、骨密度狀況皆有大幅的改善，證實搭配垂直律動不僅可以改善慢性疾病且增進健康狀況，進而提升後續健康的生活品質。

垂直律动辅助治疗慢性病的效果观察

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摘要

目的 垂直律动训练是一种新型的被动运动方法, 在运动训练和运动康复领域中应用广泛。本研究通过对社区慢性病人群进行全身垂直律动训练干预, 观察垂直律动训练干预引起的血糖、血脂、血压、骨密度及身体形态等指标的变化, 探讨切实、可行、安全、有效的运动防治慢病的新方式, 为慢性病患者运动疗法提供新的思路。

方法 本研究从某社区服务卫生中心随机筛选出 57 名中老年慢病患者, 并进行了 6 个月的垂直律动训练。干预期间每周进行 5 天训练, 每天上、下午各一次, 每次 15-30min, 在保证安全的前提下, 受试者可以选择不同的姿势进行律动, 以增加训练效果。实验干预前后做调查, 检测受试者的血糖、血脂、骨密度及身高、体重、BMI、体脂肪率、腰围、臀围等指标, 最终完成本实验者共计 48 名。

结果 (1) 受试者的体重、BMI、身体脂肪率、腰围干预前后具有显著性差异 ($p < 0.05$), 臀围干预前后差异无统计学意义 ($p > 0.05$); (2) 受试者的空腹血糖、餐后 2 小时血糖血糖干预前后具有显著性差异 ($p < 0.05$), 糖化血红蛋白干预前后不具显著性差异 ($p > 0.05$); (3) 受试者的高密度脂蛋白胆固醇干预前后具有显著性差异 ($p < 0.05$), 其他血脂指标干预前后不具显著性差异 ($p > 0.05$); (4) 受试者的血压律动前后具有显著性差异 ($p < 0.05$); (5) 受试者的骨密度干预前后具有非常显著性的差异 ($p < 0.01$)。

结论 (1) 全身垂直律动训练能降低糖尿病患者空腹血糖、餐后血糖等指标。(2) 全身垂直律动训练能改善心脏系统功能, 律动后能降低血压特别是能改善高血压患者的收缩压, 律动后心跳降低, 能提升中老年人的心肺功能。(3) 全身垂直律动训练能降低体重、BMI、身体脂肪率、腰围值; (4) 全身垂直律动训练可以通过增加骨密度来改善骨质疏松症状, 降低骨折的危险。

关键词: 垂直律动, 被动运动, 慢病管理, 健康干预

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1 引言

慢性病的患病率和死亡率呈上升趋势，已成为全球死亡的首要原因。中国慢性病发展与老龄化进展密切相关，目前，我国已进入老龄化快速发展时期，这也意味着我国进入了慢性病快速发展的加速期^[1]。目前慢性病的主要治疗方式以药物为主，但是治疗方式单一、缺乏系统性，其他辅助治疗较少。慢性病的主要危险因素与先天遗传、个人生活习惯、社会环境等有关，其中个人生活方式影响最大。实践证明，慢性病是可以预防的，对疾病的发生采取全程干预和有效的管理，可以有效的控制慢性疾病。已有大量研究证实运动能预防慢性疾病，改善常见慢性病的症状。其中一种非主动运动的方式——垂直律动训练是近年来出现的一种新的运动方式。大量的实验研究集中在垂直律动训练对运动员肌肉力量方面的研究^[2]，并且大多采用的是高频率、短时间、多组数的训练方法，然而对于普通人群特别是常见慢性病人群的研究较少，因此本文欲通过垂直律动训练法，采用低频率、时间连续的训练方式，对常见慢性病人群进行干预实验，观察垂直律动对常见慢性病的影响。

2 对象与方法

2.1 研究对象

本研究选取成都市某知名社区卫生服务中心为实验点，在相关医护人员的协助下，通过对社区人群健康档案的查阅，初步随机筛选出 36 岁以上的慢性病患者（主要以糖尿病、高血压、骨质疏松、血脂异常为主）共 64 名，再进行现场体检，对每一位患者的基本情况有所了解后，排除 7 名不适宜参加训练者，最后选取成都市武侯区跳伞塔社区卫生服务中心患者 57 名，详见表 1。

表 1 受试者人数统计情况

| 糖尿病 | 高血压 | 血脂异常 | 肥胖 | 男性 | 女性 | 平均年龄 |
|-----|-----|------|-----|-----|-----|-------|
| (人) | (人) | (人) | (人) | (人) | (人) | (岁) |
| 40 | 17 | 11 | 13 | 19 | 37 | 62.93 |

2.2 研究方法

结合受试者患病情况及律动的注意事项，初期建议受试者进行程序 3（15 分钟，0.14g）或者程序 5（20 分钟，0.2g）的律动训练方式。受试者全身放松站于盘面中心，双手持握扶柄，可以用于感应心率，随时监测心率的变化。受试者可根据自身情况做不同的姿势（或深蹲或双手平举等）。受试者适应律动并无其他不良反应后，患者可根据自身承受能力，自己调节频段的大小，以自身舒适度为益。干预期间，每周进行 5 天，每天上、下午各一次，每次 15-30 分钟，并且自己签到，记录每天律动时间。律动尽量饭后 1 小时进行，参加律动训练前建议先喝 2-3 杯的温开水，若有肾功能疾病者，可减量；律动训练后再喝 2-3 杯温开水。每次律动前及律动后测试受试者的血压，做好记录，实验期间以访谈形式询问受试者的主观感受。若律动过程中出现任何不良反应，立即停止律动，采取相应的措施缓解症状。6 个月后再次复查干预前的各项指标，得出实验结果，评价全身垂直律动对慢性病的改善效果。

3 结果

3.1 身体形态指标干预前后的变化

将所有受试者干预前后的体重、臀围、BMI、腰围、体脂肪率数据采用配对 T 检验分析，从表 2 可以看出，经过 6 个月的垂直律动训练，患者以上指标都有下降。

表 2 干预前后身体形态指标的变化 ($\bar{X} \pm s$)

| 指标 | 体重 (kg) | BMI (kg/m ²) | 体脂肪 (%) | 腰围 (cm) | 臀围 (cm) |
|-----|-------------|--------------------------|------------|------------|------------|
| 干预前 | 66.23±11.70 | 25.90±3.12 | 33.05±4.64 | 90.30±7.55 | 96.50±6.09 |
| 干预后 | 65.51±11.42 | 25.63±3.12 | 32.11±4.50 | 89.00±7.45 | 95.45±5.55 |
| t | 2.518 | 2.31 | 8.48 | 8.51 | 2.21 |
| P | 0.033 | 0.046 | 0.000** | 0.000** | 0.054 |

注：**表示 $P < 0.01$

3.2 血糖干预前后的变化

通过 6 个月的垂直振动训练，血糖相关指标变化如表 2，其中空腹血糖 (GLU) 干预后平均值从 (6.53±2.51) mmol/L 下降至 (5.92±1.53) mmol/L，下降 0.61mmol/L，具显著性差异，(t=3.29, $P < 0.05$)。餐后两小时血糖 (PBG) 干预后平均值从 (9.28±4.64) mmol/L 下降至 (7.53±2.23) mmol/L，下降

1.75mmol/L, 并且具有显著性意义, ($t=3.15, P<0.05$)。

表 3 干预前后血糖指标的变化 ($\bar{X} \pm s$)

| 指标 | GLU (mmol/L) | PBG (mmol/L) | HbA1c (%) |
|-----|--------------|--------------|-----------|
| 干预前 | 6.53±2.51 | 9.28±4.64 | 5.88±1.27 |
| 干预后 | 5.92±1.53 | 7.53±2.23 | 5.72±1.14 |
| t | 3.29 | 3.15 | 1.345 |
| P | 0.002 | 0.003 | 0.185 |

3.3 慢病患者血脂干预前后的变化

由表 4 可以看出, 经过 6 个月的垂直振动训练, 增加对人体有益的高密度脂蛋白胆固醇 (HDL-C) 干预前后具显著性差异, ($t=-2.99, P<0.05$)。

表 4 干预前后血脂指标的变化 ($\bar{X} \pm s$)

| 指标 | TG (mmol/L) | TC (mmol/L) | HDL-C (mmol/L) | LDL-C (mmol/L) |
|-----|-------------|-------------|----------------|----------------|
| 干预前 | 1.635±0.74 | 4.83±1.19 | 1.25±0.29 | 2.78±0.71 |
| 干预后 | 1.632±0.44 | 4.74±0.89 | 1.32±0.27 | 2.81±0.60 |
| t | 0.046 | 0.752 | -2.99 | -0.344 |
| P | 0.964 | 0.456 | 0.004 | 0.733 |

3.4 血压干预前后的变化

从表 5 可以看出, 受试者经过 6 个月的垂直律动训练后血压相关指标变化具有非常显著性意义

表 5 干预前后血压指标的变化 ($\bar{X} \pm s$)

| 指标 | 收缩压 (mm/Hg) | 舒张压 (mm/Hg) | 心率 (次/分) |
|-----|--------------|-------------|-------------|
| 干预前 | 126.61±14.22 | 66.97±7.57 | 80.85±10.62 |
| 干预后 | 121.01±14.40 | 65.64±7.58 | 75.85±9.74 |
| t | 11.80 | 5.39 | 19.324 |

P

0.000**

0.000**

0.000**

注: **表示 $P < 0.01$

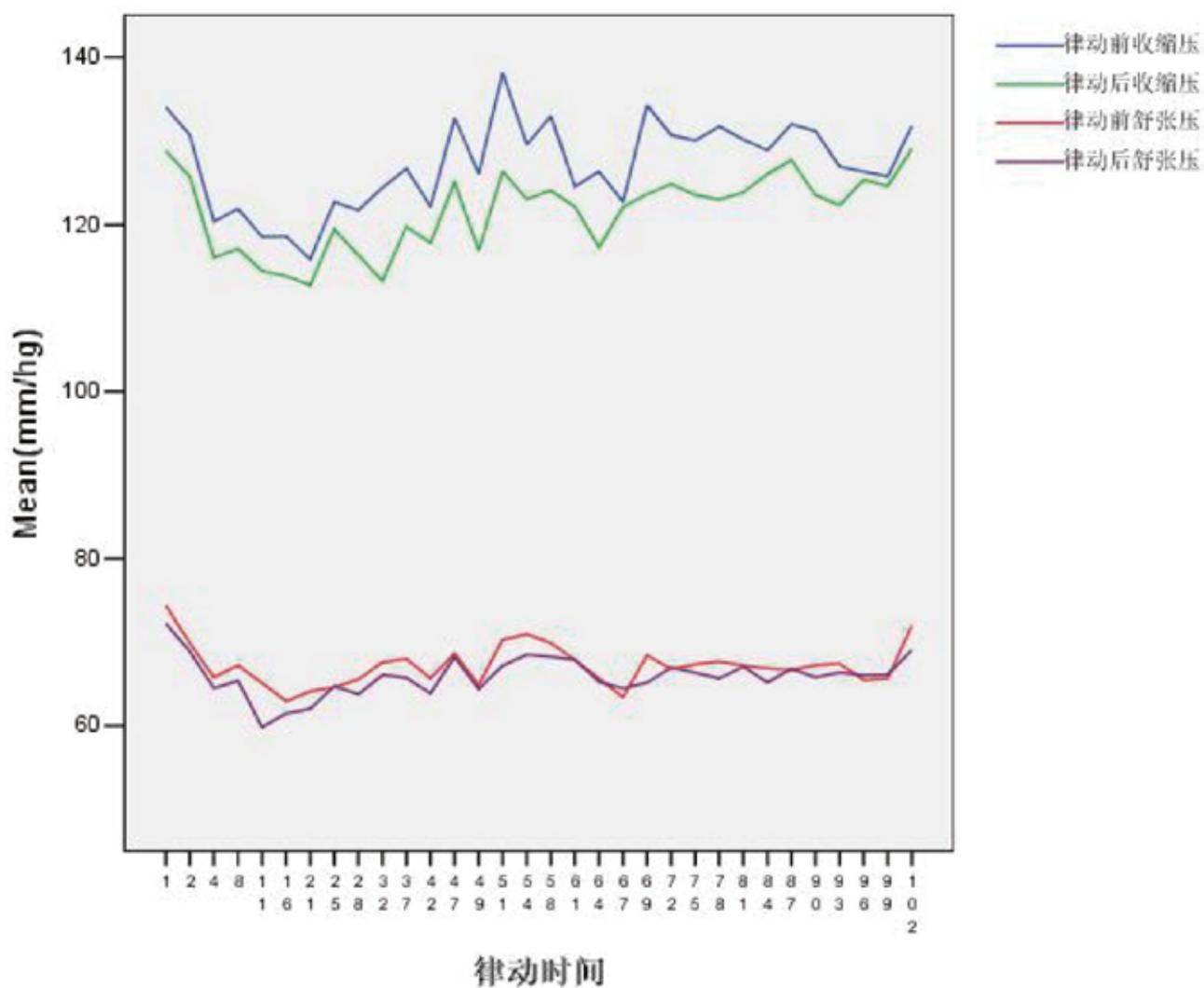


图 1 实验期间律动前后动态血压

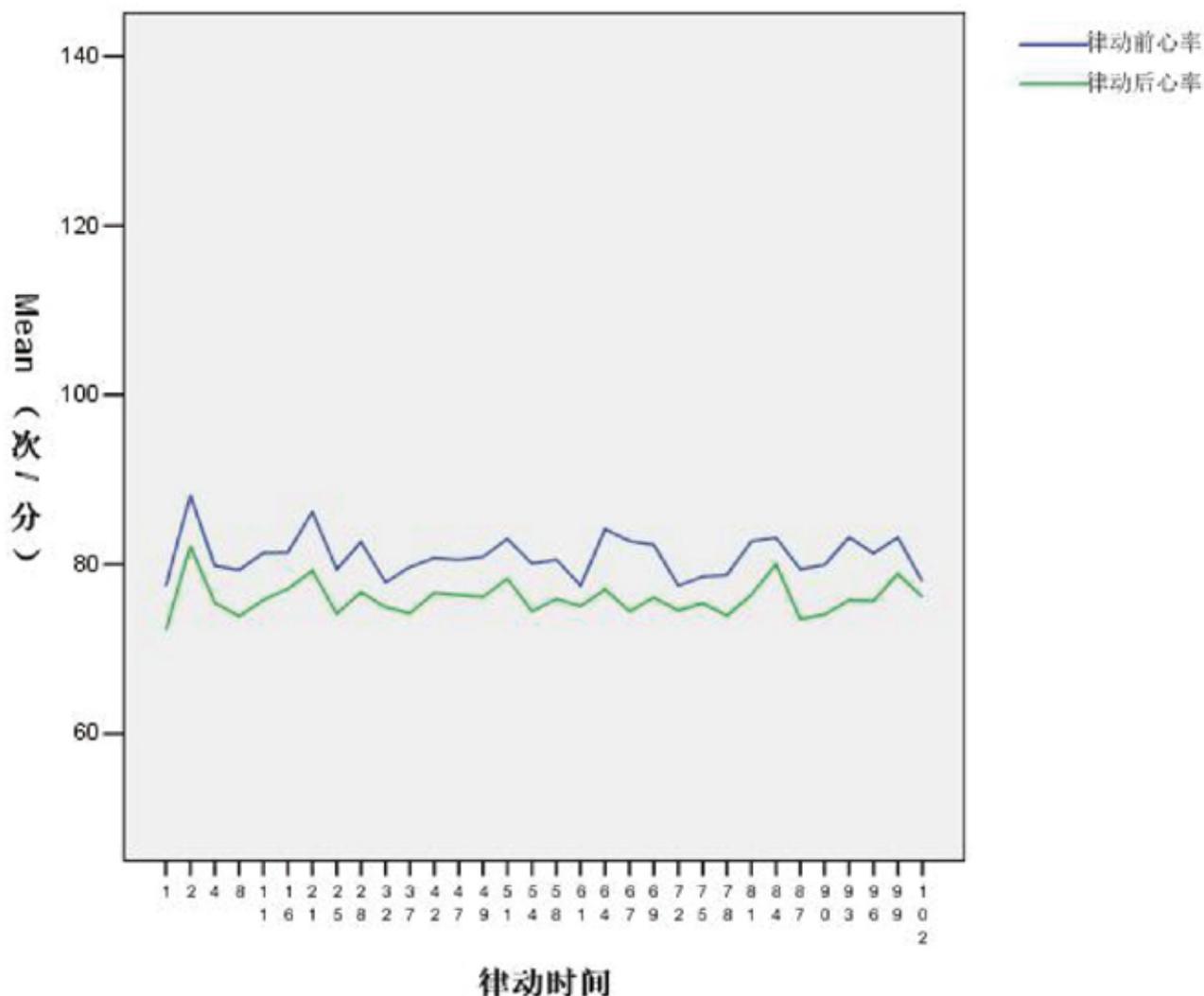


图 2 实验期间律动前后动态心率变化

由图 1 血压动态变化图可见，6 个月的律动干预后，受试者平均收缩压、舒张压值均下降，并且干预期间每次律动后都较律动前血压下降。从图 2 心率动态图可见，干预期间，受试者每次律动后的平均心率较律动前有减少。

3.5 骨密度干预前后的变化

从表 6 可见，经过 6 个月的垂直律动干预后，骨密度平均值从 $(0.427 \pm 0.097) \text{ g/cm}^3$ 增加至 $(0.453 \pm 0.092) \text{ g/cm}^3$ ，增加了 0.026 g/cm^3 ，具有显著性意义， $(t=-3.45, P<0.05)$ 。

表 6 干预前后骨密度指标的变化 ($\bar{X} \pm S$)

| 指标 | 骨密度 (g/cm ³) |
|-----|--------------------------|
| 干预前 | 0.427 ± 0.097 |
| 干预后 | 0.453 ± 0.092 |
| t | -3.45 |
| P | 0.001 |

3.6 受试者律动后主观感受变化

实验一段时间后，课题组工作人员对受试者做了一个访谈，询问受试者参与律动后的感受。前期，部分患者感觉律动后全身轻松、律动后身体微微发热；其中还有胀气感消失的、感觉有饥饿感；还有患者律动后出汗较多；还有部分患者感觉胃肠蠕动增加，大便排泄通畅；大多数患者都感觉律动后身体舒适，睡眠良好。中期又进行一次访谈询问，有一位患者反映肩周炎症有缓解；有一位患者自述体重减少；其余患者无其它特殊反映。实验后期再次访谈询问患者的感受，其中有患者自述胆结石通过律动排出了身体，还有一位慢性非阻塞性疾病及股骨头坏死的患者通过既有的呼吸机治疗再加上律动后，患者髋部疼痛的症状减轻，之前不能自己走路，通过增加律动后，患者可以走路、穿衣服，速度也较之前快，其余患者无其它特殊反映。

4 结论

6 个月的低频全身垂直律动训练能改善慢性病的核心指标和症状，是安全、可靠、低成本的辅助治疗慢性疾病的手段。垂直律动训练可以：

(1) 降低糖尿病患者空腹血糖浓度、餐后血糖浓度、糖化血红蛋白值，可改善糖尿病患者病情以及减少并发症的发生。

(2) 改善心脏系统功能，垂直律动后能降低血压特别是能改善高血压患者的收缩压，降低心跳，提升中老年人的人心肺功能。对于心血管疾病是一种新的物理治疗方式。

(3) 降低体重、BMI、身体脂肪率、腰围，改善肥胖，是一种新的减肥方

式，可以单一进行垂直律动训练或者合并其他减肥方法如节食、运动等一起使用，效果更好。

(4) 改善血脂，降低胆固醇、甘油三酯，升高对健康有好处的高密度脂蛋白胆固醇，降低心血管疾病风险。

(5) 增加骨密度，减少骨质疏松及骨折的危险。

(6) 患者不仅在生理指标方面有改善，并且有较好的身体感受，律动体验良好。

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