Journal of Physical Education and Sport ® (JPES), Vol. 22 (issue 10), Art 297, pp. 2334 - 2339, October 2022
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Effect of high intensity interval training and moderate intensity continuous training on blood pressure and blood glucose among T2DM patients

SYAFIQA RUSLAN[1], NOOR FATIHAH ILIAS[2], RAJA MOHAMMED FIRHAD RAJA AZIDIN[3], MAZLIFAH OMAR[4], ROHANA ABDUL GHANI[5], HASHBULLAH ISMAIL[6]
[1,2,3,6] Faculty of Sports Science and Recreation, Universiti Teknologi MARA Cawangan Selangor, Kampus Shah Alam, Selangor, MALAYSIA
[4,5] Faculty of Medicine UiTM Sg. Buloh Universiti Teknologi MARA, 47000 Sungai Buloh Selangor, MALAYSIA

Published online: October 31, 2022
(Accepted for publication October 15, 2022)
DOI:10.7752/jpes.2022.10297

Abstract:
Aerobic exercise has shown its own benefits. Aside from the benefits, exercise intensity plays a major role in determining the outcome of an exercise intervention. Currently, moderate intensity continuous training (MICT) and high intensity interval training (HIIT) are a well-known method of aerobic exercise. Aerobic exercise intensity may produce different acute and chronic effects in reduction of blood pressure and blood glucose among Type 2 diabetes mellitus (T2DM) patients. We measured blood pressure using automatic blood pressure monitor HEM-7322 (Omron), blood glucose monitoring (Accu-Chek) and baseline Peak VO_2 using modified Balke protocol on stationary cycle ergometer. During exercise intervention, pre and post blood pressure and blood glucose was measured in each exercise session three times a week. Total exercise volume for each participant in both groups are fixed and the training program for both groups will be properly designed to yield the same energy expenditure for 7 weeks. High Intensity Interval Training (HIIT) was conducted for 30 minutes per session every stage consisting of 3 minutes' aerobic exercises and 1-minute active rest. Work intensity will be above 85% heart rate reserve (HRR) thus rest intensity will be < 30-40% HRR and the training volume will be around 250kCal. Next, Moderate intensity continuous training (MICT) was conducted for 50 minutes 40<60% HRR and the training volume will be 250kCal. A paired-sample t-test was conducted to evaluate the acute effect for every session of exercise on SBP, DBP and BG. There was a statistically significant difference on acute effect on SBP at week 6 and 7 with p = 0.13 and 0.34 for HIIT groups and at week 1, 2, 5, 6 and 7 with p = 0.001, 0.002, 0.015, 0.10 and 0.23 for MICT groups. However, no significant difference between two groups (HIIT and MICT) has an acute effect on changes of reduction on SBP, DBP and BG, p >.05. A mixed between-within ANOVA was conducted to compare the effect of two different exercise intensities (HIIT and MICT) on systolic blood pressure (SBP), diastolic blood pressure (DBP), and blood glucose (BG) among T2DM patients. There was also no significant difference in chronic effect on SBP, DBP and BG from baseline or first weeks of exercise, week four and at week seven p > 0.05 (two-tailed) between both groups of exercise intensities by using paired sample tests. In conclusion, different aerobic exercise intensity may have different acute effects on blood pressure and blood glucose among T2DM patients. Our findings suggest that both groups are giving similar responses compared to each other relatively due to shorter periods of training.
Key Words: **Aerobic Exercise, Exercise intensity, High Intensity Interval Training, Moderate Intensity Continuous Training, Type 2 Diabetes Mellitus**

Introduction

Diabetes mellitus is a group of metabolic diseases characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Lifestyle changes including the adoption and maintenance of physical activity are the cornerstones to the prevention and delay of incidence of T2DM. The potential benefits of exercise in management and control of diabetes among T2DM patients have been acknowledged by many people. Physical exercise is the first line treatment for patients with T2DM through lifestyle changes (Ismail, 2013). Physical exercise with certain intensity is can be as a powerful tool in diabetes management and one of inexpensive yet effective ways to control diabetes complications and an important non-pharmacological intervention for T2DM. Intensities of exercise may play an important factor in the reduction of cardiovascular responses and glycemic control.

However, the optimal exercise that will result in greater benefit in T2DM remains unclear. Despite the several published studies about the benefits of HIIT in patients with T2DM, very few have analysed its acute efficacy on glycemic control and cardiovascular responses in this population and in direct comparison with MICT. Different exercise intensity may have different acute effects on cardiovascular responses and glycemic control.

Corresponding Author: HASHBULLAH ISMAIL, E-mail: hashbullah@uitm.edu.my

Material & Methods

Research Design

The experimental design was selected because a study was proposed to determine the acute and chronic effect of different exercise intensities between HIIT and MICT throughout 7 weeks of exercise duration on SBP, DBP, and BG among T2DM patients. In this study, patients were randomly assigned into two groups to equalize the characteristics of each group in this study.

Participants and Target Population

The participants in this study were T2DM patients who are receiving the treatment in Hospital UiTM Sungai Buloh and antihypertensive and T2DM drugs. A total participant was (n = 10) who volunteered to participate in this study, four females, while the rest were males (n = 6). The inclusion criteria such as more than 6 months of diabetes with SBP 160 mmHg and DBP 100 mmHg, age between 30-60 years old and sedentary lifestyle and exclusion criteria such as no case uncontrolled hypertension, uncontrolled blood pressure > 160/100 mmHg, all diabetic foot ulcers involving the sole of the foot, neuromuscular diseases cause limitation to perform exercise, myocardial infarction (within past 6 month), any unstable chronic condition, including dementia, alcoholism, dialysis, retinal haemorrhage or detachment, kidney failure, autonomic neuropathy, osteoarticular diseases. A fishbowl method was used to randomize into two groups which are HIIT and MICT.There is one patient in MICT who was not able to complete the study due to pandemic COVID 19 in March 2020. All the data were included in the analysis through their last session on 7-week intervention except for one patient in the MICT group only had time for an intervention at week four. Four participants in HIIT (n = 4) and MICT (n = 6) were fully participating in this study.

Cardiovascular Responses and Blood Glucose Analysis

Cardiovascular response analysis was based on Peak VO_2, systolic blood pressure (SBP), diastolic blood pressure (DBP) and resting heart rate (RHR) and blood glucose (BG) during pre-test and exercise intervention for T2DM participants. Peak VO_2 is the highest value that was attained during exercise. It was measured separately with exercise stress testing using modified Balke protocol on a stationary cycle ergometer at Sports Lab UiTM Shah Alam. Maximal exercise testing where the workload was increased, and the increment of the stage was based on the participant's ability. In this study, blood pressure was evaluated by using an automatic blood pressure monitor HEM-7322 (Omron). Fingertip pulse oximeter (Model: MD300C29) is used to measure the heart rate and oxygen saturation at rest and during exercise. It is a common device to check blood oxygen saturation level and heart rate. The blood glucose assessment was monitored before Peak VO_2, testing on a stationary cycle ergometer started.

Intervention

Exercise training intervention for both groups involved aerobic exercise using a stationary bicycle ergometer (Biodex). Exercise volume or energy required for each session of exercise for both groups was about 250 kcal per session and up to 750 kcal per week. Before each exercise session, blood pressure, heart rate, blood glucose was monitored after 10 minutes of coming in sitting position with the armrest on the table as a pre-exercise data. In addition, participants were asked related to any complication to exercise such as musculoskeletal discomfort or any other sign and symptoms of high blood pressure like nauseas, vomiting, and blurred vision as a safety measure before starting exercise. After each exercise session, blood pressure, heart rate, and blood glucose were monitored. Besides, participants were reminded to follow the medication schedule. The participants underwent different exercise intensities which are HIIT and MICT throughout 7 weeks of exercise duration for three times/week.

High Intensity Interval Training (HIIT)

Participants have a warm-up session for 5 minutes to increase heart rate reserve by 20%-40%. Exercises were conducted in four stages and every stage consists of 3 minutes' aerobic exercises and 1-minute active rest. Work intensity was above 85% heart rate reserve (HRR) thus rest intensity was < 30-40% HRR and the training volume was 250 kcal. Cooling down session for 5 minutes to reduce body temperature and heart rate while maintaining the blood circulation was commenced shortly after the training interval was finished. This intervention lasted for 30 minutes per session. Refer table 1.

Table 1: Exercise Intervention for HIIT

	Time (min/sec)		**Intensity (% HRR)**
Warm Up	5 minutes		20-40 % HRR
Exercise	Work time	Rest	Work intensity
	3	1	≥85% HRR
	3	1	Rest intensity
	3	1	20-40% HRR
	3	1	
	3		
Cooling Down	6 minutes		20-40% HRR
Total Exercise Time	30 minutes		
Total Volume	250 kcal		

Moderate Intensity Continuous Training (MICT) Participants have warm-up for 5 minutes to increase their heart rate reserve about 20-40%. Next, exercises were conducted for 4 minutes with 40<60% HRR and the ***training***

volume was 250 kcal. Cooling down session for 5 minutes was commenced shortly after the training interval was finished. This intervention lasted for 55 minutes per session. Refer table 2.

Table 2: Exercise Intervention for MICT

	Time (min/sec)	Intensity (% HRR)
Warm Up	5 minutes	20-40% HRR
Exercise	45	40-60% HRR
Cooling Down	5 minutes	20-40% HRR
Total Exercise Time	55 minutes	
Total Volume	250 kcal	

Statistical Analysis

All the data will be analysed by using Statistical Package of Social Sciences (SPSS) program software version 26.0. Descriptive statistics such as frequency, mean (M), standard deviation (SD), were used to describe the demographic variables of the participants such as age, height, weight, year of diabetes, and number of antihypertensive drugs and diabetic medication. A paired-sample t-test was conducted to evaluate the acute effect for every session of exercise on SBP, DBP and BG. A mixed between-within ANOVA was conducted to compare the effect of two different exercise intensities (HIIT and MICT) on systolic blood pressure (SBP), diastolic blood pressure (DBP), and blood glucose (BG) among T2DM patients and paired sample test was conducted to determine the chronic effect on SBP, DBP, and BG for pre (week 1), Intermediate (week 4) and post (week 7) exercise intervention for both exercise groups. The significant value was set at $p < .05$. A significant F test indicates that the null hypothesis is rejected. A paired-samples t-test was conducted to evaluate the impact of the HIIT and MICT on SBP, DBP and BG.

Results

The Acute Effect of Aerobic Exercise on Systolic Blood Pressure

Table 1 showed SBP was measured before and after the exercise intervention for both groups in every session of exercise intervention. The data were presented by a week for seventh weeks of exercise duration.

Table 1: Systolic Blood Pressure Before and After High Intensity Interval Training.

Week		Before		After				
SBP	N	M	SD	M	SD	t	Sig. (2-tailed)	Mean Difference
Baseline/1	4	133.17	10.31	126.42	13.00	3.09	.054	6.75
2	4	134.92	6.20	124.25	11.26	3.15	.051	10.67
3	4	133.92	11.20	127.08	11.10	2.53	.085	6.83
4	4	129.58	13.20	125.08	10.12	.977	.400	4.50
5	4	132.17	8.34	125.17	9.99	2.66	.077	7.00
6	4	136.17	10.86	127.67	8.16	5.27	.013*	8.50
7	4	132.92	8.52	125.83	8.52	3.72	.034*	7.08

A paired-sample t-test was conducted to evaluate the acute effect for every session of exercise on systolic blood pressure (SBP) among T2DM patients. There was a statistically significant difference at week 6 and 7 with p = 0.13 and 0.34. Results showed SBP before exercise at the baseline/1 for HIIT group was (M = 133.17, SD = 10.31) mmHg and end of seven weeks was (M = 132.92, SD = 8.52) mmHg. The highest SBP before exercise was during week six (M = 136.17, SD = 10.86) and the lowest during week four (M = 129.58, SD = 13.20) was resulted. Meanwhile, SBP after exercise at the baseline/1 for HIIT group was (M = 126.42, SD = 13.00) mmHg and end of seven weeks was (M = 125.83, SD = 8.52) mmHg. The highest SBP after exercise was during baseline/1 (M = 127.67, SD = 8.16) and the lowest during week seven (M = 124.25, SD = 11.26) was resulted after HIIT interventions. Refer figure 1.

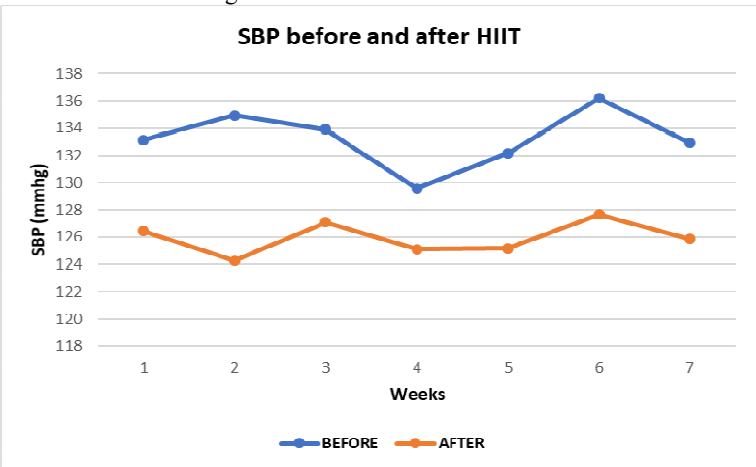

Figure 1: Systolic Blood Pressure Before and After High Intensity Interval Training

Results showed SBP before exercise at the baseline/1 for MICT group was (M = 135.22, SD = 11.15) mmHg and end of seven weeks was (M = 129.00, SD = 4.78) mmHg. The highest SBP before exercise was for the first week (M = 135.22, SD = 11.15) and the lowest during week three (M = 128.06, SD = 14.43) was resulted. Meanwhile, SBP after exercise at the baseline/1 for MICT group was (M = 123.39, SD = 11.56) mmHg and end of seven weeks was (M = 125.73, SD = 4.38) mmHg. The highest SBP after exercise was during week seven (M = 125.73, SD = 4.38) and the lowest during week five (M = 119.60, SD 5.36) was resulted after MICT intervention. There was a statistically significant difference of SBP at week 1,2,5,6 and 7 with p = 0.001,0.002,0.015,0.10 and 0.23.

The Acute Effect of Aerobic Exercise on Diastolic Blood Pressure

Results showed DBP was measured before and after the exercise intervention for both groups in every session of exercise intervention. The data were presented by a week for seventh weeks of exercise duration. Results showed DBP before exercise at the baseline/1 for HIIT group was (M = 82.42, SD = 2.56) mmHg and end of seven weeks was (M = 81.75, SD = 4.95) mmHg. The highest DBP before exercise was for second week (M = 83.00, SD = 2.68) and the lowest during week five (M = 79.17, SD = 1.91) was resulted. Meanwhile, DBP after exercise at the baseline/1 for HIIT group was (M = 80.42, SD = 3.47) mmHg and end of seven weeks was (M = 78.54, SD = 7.03) mmHg. The highest DBP after exercise was during week three (M = 82.00, SD = 7.22) and the lowest during week five (M = 77.92, SD = 6.33) was resulted after HIIT intervention. There was a statistically significant difference on DBP at week 2 with p = 0.013.

Results showed DBP before exercise at the baseline/1 for MICT group was (*M* = 80.67, *SD* = 7.70) mmHg and end of seven weeks was (*M* = 75.67, *SD* = 2.66) mmHg. The highest DBP before exercise was during baseline/1 (*M* = 80.67, *SD* = 7.70) and the lowest during week six (*M* = 76.00, *SD* = 8.81) was resulted. Meanwhile, DBP after exercise at the baseline/1 for MICT group was (*M* = 76.00, *SD* = 9.63) mmHg and end of seven weeks was (*M* = 72.93, *SD* = 1.96) mmHg. The highest DBP after exercise was during week baseline/1 (*M* = 76.00, *SD* = 9.63) and the lowest during week seven (*M* = 72.93, *SD* = 1.96) was resulted after MICT intervention. There was a statistically significant difference on DBP at week 1 with p = 0.030.

The Acute Effect of Aerobic Exercise on Blood Glucose

Table 2 showed BG was measured before and after the exercise intervention for both groups in every session of exercise intervention. The data were presented by a week for seventh weeks of exercise duration.

Table 2: Blood Glucose Before and After High Intensity Interval Training.

Week		Before		After				
BG	**N**	**M**	**SD**	**M**	**SD**	**t**	**Sig. (2-tailed)**	**Mean Difference**
Baseline/1	4	9.21	1.41	6.32	1.88	5.26	0.013*	2.89
2	4	8.67	1.48	5.80	1.49	3.65	0.035*	2.87
3	4	8.97	2.91	6.11	1.58	3.58	0.037*	2.86
4	4	8.33	2.47	5.76	1.26	4.05	0.027*	2.57
5	4	9.08	4.70	6.70	3.22	3.09	0.054	2.38
6	4	9.30	2.28	6.15	1.21	4.64	0.019*	3.15
7	4	8.71	2.62	5.91	0.86	2.64	0.077	2.80

Results showed BG before exercise at the baseline/1 for HIIT group was (M = 9.21, SD = 1.41) mmol/L and end of seven weeks was (M = 8.71, SD = 2.62) mmol/L. The highest BG before exercise was for six weeks (M = 9.30, SD = 2.28) and the lowest during week four (M = 8.33, SD = 2.47) was resulted. Meanwhile, BG after exercise at the baseline/1 for HIIT group was (M = 6.32, SD = 1.88) mmol/L and end of seven weeks was (M = 5.91, SD = O.86) mmol/L. The highest BG after exercise was during week five (M = 6.70, SD = 3.22) and the lowest during week four (M = 5.76, SD = 1.26) was resulted after HIIT intervention. There was a statistically significant difference on BG at week 1,2,3,4 and 6 with p = 0.013,0.035,0.037,0.027 and 0.019. Refer figure 2.

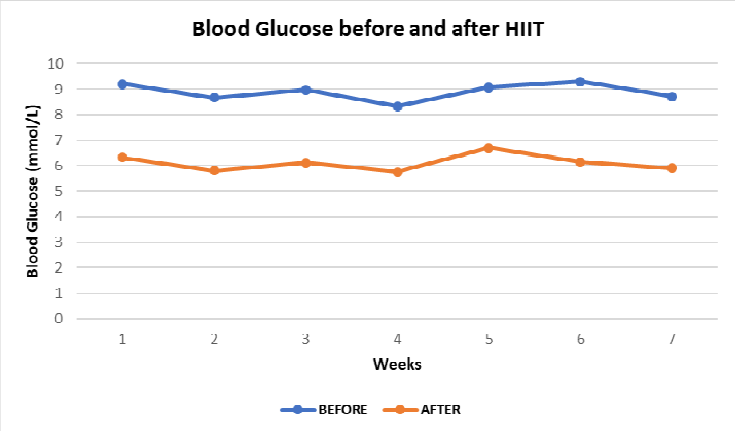

Figure 2: Blood Glucose Before and After High Intensity Interval Training

Results showed BG before exercise at the baseline/1 for MICT group was (M = 8.32, SD = 2.40) mmol/L and end of seven weeks was (M = 8.57, SD = 1.61) mmol/L. The highest BG before exercise was for five weeks (M = 9.03, SD = 1.87) and the lowest during week three (M = 8.18, SD = 2.16) was resulted. Meanwhile, BG after exercise at the baseline/1 for MICT group was (M = 6.56, SD = 1.01) mmol/L and end of seven weeks was (M = 7.03, SD = 1.50) mmol/L. The highest BG after exercise was during week seven (M = 7.03, SD = 1.50) and the lowest during week three (M = 5.89, SD = 0.86) was resulted after MICT intervention. There was a statistically significant difference on BG at week 2,4 and 5 with p = 0.023, 0.028 and 0.015.

The Chronic Effect between HIIT and MICT on SBP, DBP and BG

A paired-samples t-test was conducted to evaluate the impact of the HIIT and MICT on SBP, DBP and BG. There was no significant difference between HIIT and MICT for pre- and post-of exercise session on SBP in four weeks, t (9) = 0.21, p = 0.843. There was no significant difference between HIIT and MICT for pre- and post-of exercise session on SBP in seven weeks, t (9) = 0.36, p = 0.729. There was no significant difference between HIIT and MICT for pre- and post-of exercise session on DBP in four weeks, t (9) = -1.18, p = 0.273. There was no significant difference between HIIT and MICT for pre- and post-of exercise session on DBP in seven weeks, t (9) = 0.37, p = 0.720. There was no significant difference between HIIT and MICT for pre- and post-of exercise session on BG in four weeks, t (9) = 1.52, p = 0.167. There was no significant difference between HIIT and MICT for pre- and post-of exercise session on BG in seven weeks, t (9) = 0.48, p = 0.649.

Discussion

HIIT group showed no statistically significant difference on the acute effect for every session of exercise on systolic blood pressure (SBP) except at week 6 and 7 among T2DM patients. There is a possibility that the long duration of exercise training may be more effective than shorter duration training by improving vascular function with involvement of the renin-angiotensin system and sympathetic nervous system. Other possible factors that reduce the SBP could be due to diminishing plasma volume, increase vasodilation substances and change in the hormone.

There was a statistically significant difference on DBP with HIIT group at week 2 and MICT group at week 1. Aerobic exercise may reduce diastolic blood pressure (DBP) although it is usually reported that throughout changes in the exercise intensity may change little on DBP (Akter, 2017). It can be suggested that changes in DBP can range from a slight decrease due to the mechanism from vasodilation of the muscle vasculature from the occlusion of blood flow caused by the forceful contractions of the exercising muscles. There were changes occurring in the large arteries, including inflammation, elastic fragmentation and metabolic stress and with moderate and high intensity aerobic exercise may help to reduce DBP.

From this study result, it showed that both HIIT and MICT significantly decrease blood glucose (BG). Although improvements of glucose metabolism are observed during MICT intervention, more pronounced effects are seen during HIIT intervention. HIIT has a more positive effect on BG due to HIIT may cause a larger proportion of muscle fibres and improve of insulin sensitivity. The insulin transportation and insulin sensitivity become efficient, thereby reducing blood sugar and inhibiting excessive insulin in T2DM patients.

There was no significant difference between HIIT and MICT group for blood pressure and blood glucose in exercise intervention. Both modalities HIIT and MICT showed similar effects on systolic and diastolic blood pressure in individuals with T2DM. There was no significant difference of HIIT and MICT on BG among T2DM patients for chronic effect of aerobic exercise.

Conclusions

Exercise training appears to be effective and it was recommended therapy for management T2DM patients. This body of work has extended understanding of the benefit of exercise training in T2DM patients. This study indicates that both groups HIIT and MICT are giving similar responses compared to each other relatively due to shorter periods of training. Perhaps the chronic effect of aerobic training can show very good results in more variables for T2DM patients exercise guidelines. These studies suggest that patients who can comply with exercise training may improve blood glucose and blood pressure to delay the risk of cardiovascular diseases and to reduce metabolic disease.

Acknowledgment: The project is partially funded through a Lestari SDG grant (600-RMC/LESTARI SDG-T 5/3 (152/2019)) Universiti Teknologi MARA.

Conflicts of interest: No conflicts of interest are declared by the authors.

References

Akter, S., Goto, A., & Mizoue, T. (2017). Smoking and the risk of type 2 diabetes in Japan: A systematic review and meta-analysis. In *Journal of Epidemiology*. https://doi.org/10.1016/j.je.2016.12.017

Cornelissen, V. A., & Fagard, R. H. (2005). Effects of endurance training on blood pressure, blood pressure-regulating mechanisms, and cardiovascular risk factors. *Hypertension*, *46*(4). https://doi.org/10.1161/01.HYP.0000184225.05629.51

De Nardi, A. T., Tolves, T., Lenzi, T. L., Signori, L. U., & Silva, A. M. V. da. (2018). High-intensity interval training versus continuous training on physiological and metabolic variables in prediabetes and type 2 diabetes: A meta-analysis. In *Diabetes Research and Clinical Practice*. https://doi.org/10.1016/j.diabres.2017.12.017

Kemps, H., Kränkel, N., Dörr, M., Moholdt, T., Wilhelm, M., Paneni, F., Serratosa, L., Ekker olberg, E., Hansen, D., Halle, M., & Guazzi, M. (2019). Exercise training for patients with type 2 diabetes and cardiovascular disease: What to pursue and how to do it. A Position Paper of the European Association of Preventive Cardiology (EAPC). *European Journal of Preventive Cardiology*. https://doi.org/10.1177/2047487318820420

Ismail, H., J. McFarlane, G. Dieberg, H. Noujimian and N.A. Smart Clinical Outcomes and Cardiovascular Responses to Different Exercise Training Intensities in Heart Failure Patients: A systematic review and meta-analysis. JACC: Heart Failure, 2013, 1(6): pp 514-22