科技部補助專題研究計畫成果報告
期末報告

漸增式極限運動時的氧脈衝型態研究-於正常人、慢性阻塞性肺病人與心衰竭病人的差異研究 －可能的機轉

計 畫 類 別 ： 個別型計畫
計 畫 編 號 ： MOST 106-2314-B-040-025-
執 行 期 間 ： 106年08月01日至108年07月31日
執 行 單 位 ： 中山醫學大學醫學系

計 畫 主 持 人： 莊銘隆
共 同 主 持 人： 謝孟哲、蔡青峰、高潘福、丁化、曹昌堯
吳子卿、王耀震、翁瑞鴻
計畫參與人員： 其他-兼任助理：陳佳汶
其他-兼任助理：陳珮綾
其他-兼任助理：石雅云
其他-兼任助理：吳舒涵
其他-兼任助理：范紫歆
其他-兼任助理：林玲慧

中 華 民 國 108 年 11 月 15 日

中 文 摘 要 ： 背景:氧脈衝(簡稱O2P*)在無創運動心肺功能學(CPET*)裡，等於O2 uptake除以心跳，也是心臟搏出體積(VS*)乘以全身組織細胞對氧氣攫取量(oxygen extraction)，代表每一次心跳供應全身組織細胞氧氣消耗量的能力。在CPET裡，O2P視同VS。因此，CPET-O2P便可無創連續地監測運動中VS的變化。O2P值(指%預測值)與心衰竭程度、預後相關;與慢性阻塞性肺病(COPD)病人的肺殘氣(air trapping)擠壓心臟而無法開展繼而失能相關。
假說與目的:O2P的型態鮮少被探討；O2P呈現高原型或甚至遞減且O2P值降低，假設是心衰竭或運動到心肌缺氧造成心肌的失能所致。本計畫欲探討O2P型態(1)正常人、心衰竭、COPD病人各有幾種?(2)與心衰竭、COPD病人心功能相關?本計畫的結果可能提供CPET判讀的重要參考，目前文獻上未有相關報告。
方法:多醫學中心、跨領域、前瞻性、一次性、比較性的橫斷面研究。40-85歲、BMI*18-28，將正常人、心衰竭與COPD受試人各40、80、80人入組，平均分2年執行。COPD符合GOLD指引。心衰竭符合ESC*指引，NYHA*功能等級為一至三級。3組人皆做CPET，病人組須作心臟超音波、first pass及myocardial perfusion核醫檢查。主要測量O2P型態、心臟超音波、first pass心臟功能及心肌灌流和肺殘氣。執行CPET前，病人組須停藥一-三天救急的藥除外。
分析:連續變項(O2P值)常態分布採t-test、ANOVA分析，非常態分布採 Mann-Whitney。非連續變項(O2P型態)採chi-square或Fisher’s exact test。P<0.05認定有統計差異。統計軟體採SAS。

中 文 關 鍵 詞 ： 氧脈衝(簡稱O2P)
運動心肺功能測試(CPET)
心臟搏出體積(VS)
氧氣攫取量(oxygen extraction)

英 文 摘 要 ： Background: In non-invasive cardiopulmonary exercise testing (CPET), oxygen pulse (O2P) is defined as oxygen uptake divided by heart rate and is equal to the product of stroke volume and oxygen extraction by cells. As per, the O2P indicates the capability of oxygen consumption of whole body tissues and cells per heart beat. During exercise, the O2P changes can be deemed as the stroke volume changes as the oxygen extraction by muscle cells are normal. Hence, CPET-O2P can be non-invasively and continuously used to monitor the stroke volume changes during exercise. O2P value (i.e., % of predicted) is related to the severity and prognosis of heart failure and to the severity of constraint of the heart caused by exercise-induced hyperinflation or air trapping in patients with chronic obstructive pulmonary disease (COPD). However, O2P plateau pattern is not uncommonly encountered in the daily practice.
Hypothesis and aims: O2P patterns during incremental exercise are seldom investigated although they have been hypothesized that the plateau or decreasing patterns are

related to myocardial failure or ischemia. In this proposal, the O2P patterns are to be thoroughly investigated: (1) the patterns in norms, patients with heart failure and COPD, (2) the relationship between the O2P pattern and cardiac function and/or myocardial ischemia in patients with heart failure and COPD. As yet there are no relative reports on the O2P pattern and its possible mechanisms in the literature, the results of the proposal might tremendously impact the interpretation strategy of CPET reports.
Methods: Multi-center, multidisciplinary, prospective, comparative cross-sectional study is designed. Subjects aged from 40-85 years with the BMI of 18-28kg/m2 are to be enrolled: sample sizes of the norms, heart failure and COPD groups are 40, 80, and 80, respectively, equally distributed in two years. The definitions of COPD and heart failure with NYHA class I-III are according to the GOLD and ESC guidelines, respectively。All the three groups undergo CPET measurement; the patient groups undergo echocardiography, and the first pass and myocardial perfusion studies using Tc-99. The primary measurements are the O2P patterns and the cardiac function measured with echocardiography, the first pass and myocardial perfusion studies and air trapping in the lungs. Patients have to stop medications except rescue medications one to three days before CPET.
Statistical analysis: For normal continuous data, t-test or ANOVA is used. For non-normal data, the Mann-Whitney test is used. The chi-square test or Fisher’s exact test is used to compare the proportion of categorical variables between the two groups. A p value of less than .05 is considered to be statistically significant. Statistical procedures are performed using the SAS software package version 9.3.

英文關鍵詞：*O2P: oxygen pulse, CPET: cardiopulmonary exercise testing, VS: stroke volume, BMI: body mass index, ESC: European Society of Cardiology, NYHA: New York Heart Association

科技部期末報告

目錄

一、前言

運動中的心臟功能(心搏容積 stroke volume)不容易測得，遑論要連續測得。運動心肺功能測試的 Oxygen pulse(O_2P)可以代表它[1]，特別是它的型態學—高原型 O_2P，已被許多學者建議當作運動中心肌缺氧的指標，搭配 EKG，可提高診斷率[2]，尤其是它可以連續測得，在一段運動時間中，更能看它的變化趨勢。但是它的獨特性有受到質疑，特別是 COPD 病人的變化情況，最近我們已提出佐證[3]。至於正常人與心衰竭病人會如何與各種型態的機轉如何，尚不得而知。

二、研究目的

O_2P 的型態鮮少被探討；O_2P 呈現高原型或甚至遞減且 O_2P 值降低，假設是心衰竭或運動到心肌缺氧造成心肌的失能所致。本研究欲探討 O_2P 型態(1)正常人、心衰竭、COPD 病人各有幾種? (2)形成各種型態的可能原因機轉為何?與心衰竭、COPD 病人心功能相關?本研究的結果可能提供 CPET 判讀的重要參考。

三、研究方法

以多醫學中心、跨領域、前瞻性、一次性、比較性的橫斷面研究。期間: 2017/8/1-2018/7/31 and 延期 2018/8/1-2019/7/31。地點:中山醫學大學附設醫院與嘉義長庚醫院胸腔科、心臟科、核醫科、健檢中心。進行的流程圖(Figure 1):

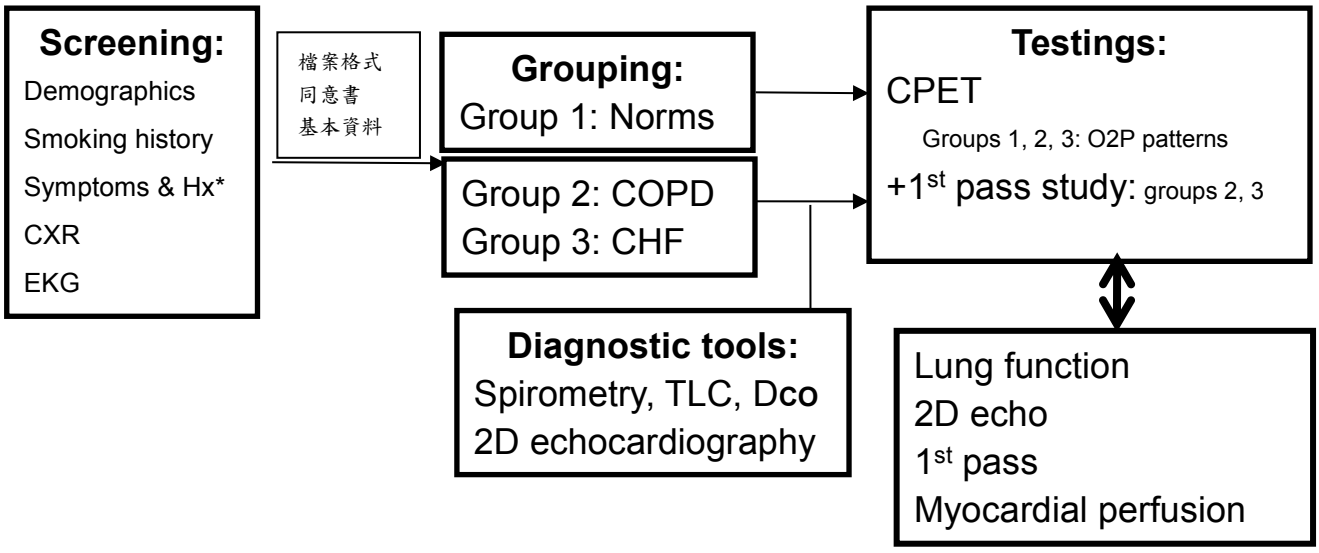


Figure 1. 收案與分組檢測流程圖。箭頭: 流程走向，雙箭頭:雙邊相關性分析。執行 2D echocardiography、1st pass study、CPET 前須停藥一天至三天(視藥物而定)，應急的藥除外。[2] Nitrates for 24 hours, calcium antagonists for 48 hours, bea-blockers for 3 days. Tea, coffee, cola-drinks, chocolate and smoking were not allowed for 24 hours before the evaluation[4].

對象: 納入條件 (1) COPD 受試者年齡 40-85 歲男女符合 2017 COPD GOLD 準則定義[5]，菸齡≥10 包·年或有明確燃煤史，抽菸量維持在最低量(不能沒有努力減少

菸量)或已經戒了，穩定期的肺功能為吸入支氣管擴張劑後 $FEV_1/FVC \leq 0.7$，對吸入型支氣管擴張劑無明顯反應(FEV_1 後前差≥+200mL 或≥+12%)，FEV_1<80%預測值，一個月內無急性惡化現象，依據 2017 COPD GOLD 準則治療，未有新介入的運動訓練計劃。(2)心衰竭受試者年齡 40-85 歲男女符合 the European society of cardiology (ESC)[6] 準則定義，NYHA 功能等級為一至三級，一年內心臟超音波檢查 ejection fraction <45%(40-50%)，一個月內無急性惡化現象，依據 ESC 準則治療。(3)正常受試者年齡 40-85 歲男女無明顯病史，且健康檢查無明顯疾病，如嚴重高血壓、輕微高血壓未控制[7]、其他心血管病、糖尿病、腎病、其他胸腔病、肝病、風免病、癌症、貧血、精神病、會影響下肢運動病變；當下未有急性病。主要來源來自健檢中心。以上三種受試者皆願意參與此項研究，並有簽屬諮情同意書。<u>排除條件:</u> 胸廓病、嚴重心律不整、未控制的糖尿病或高血壓、末期慢性病包括腎臟病風濕免疫病、癌症、貧血(Hb <10 g/dL), atrial fibrillation or flutter, recent (less than 3 months) acute coronary syndrome, recent (less than six months) percutaneous or surgical revascularization, left-bundle-branch block, pacemaker, or inability to exercise.[2] COPD 受試者有心衰竭、冠心病、嚴重心律不整者。心衰竭受試者有 30%有阻塞性肺病包括氣喘或其他肺病[8]，嚴重心律不整者都必須排除。<u>人數估算:</u> 共分 3 組，COPD 與心衰竭受試者以組內 ejection fraction 差異 10%、標準差 6%，以α 值 0.05 和檢力 0.8 估算，各含 10%退出率，2 組人數各為 80 位。正常受試者應無明顯 ejection fraction 差異，入組人數 40 位，平均分 2 年執行(經費僅一年，延期)。

進行步驟: (1)篩選期: COPD 受試者由胸腔科醫師轉介，心衰竭受試者由心臟科醫師轉介(見 Appendix) 篩選包含 demographic data、病史、 CBC、DC、Cr、Na、K、GOT、GPT、Bil(T)、sugar(pc)、hs-CRP、CXR、EKG。

(2)確認診斷: (a) spirometry lung volumes diffusing capacity: Forced expired volume in one second (FEV_1), total lung capacity, and residual volume were measured with a pressure-sensitive body plethysmograph (MasterScreen Body, Carefusion, Leibnizstrasse, Wuerzburg, Germany) at body temperature, ambient atmospheric pressure, and when fully saturated. The best of three technically satisfactory readings was used.[9] All of the lung function data were obtained after inhaling 400 μg of fenoterol HCl. The diffusing capacity for carbon monoxide (D_LCO) was measured by the single-breath technique.[10] Direct maximum voluntary ventilation (MVV) was performed and calculated from a 12-second maneuver of rapid and deep breathing as recommended for patients with COPD.[11] Simple volume calibration was conducted with a 3-L syringe before each test. (b) Two-dimensional echocardiography (iE33, Philips, Seattle, USA) was performed by the experienced cardiologists who were blind to the clinical data, lung function, the 1st pass study, and CPET reports within four weeks before CPET. If there were acute exacerbations of COPD in the time between the two tests, one of the tests would be postponed. Parasternal, apical and

subcostal studies of echocardiography were conducted and the definitions of cor pulmonale and ejection fraction were used according to previous reports.[12-14] 3 組受試者皆執行。因為設備的緣故，First pass study 在 CPET 完成後進行，雖然已知固定實驗順序會產生 bias 但無法避免。

(3) 實驗儀器與測量: (a) CPET:受試者坐在運動腳踏車上達穩定態，空踩 2 分鐘後，電腦控制運動腳踏車的瓦數均勻上升，預估在 10±2 分鐘內達到受試者症狀的極限[15]，而後停止瓦數，慢慢恢復。監測氧氣消耗量、CO_2 排出量、換氣量、心率及其相關衍算出的參數、心電圖、S_PO_2、血壓。

(b)放射核種 the first pass 測量 ejection fraction 及肺動脈的 transit time: 放射核種第一次穿流心臟血管攝影可以配合 Tc-99m 標誌的放射藥物注射，例如心肌灌注造影的 Tc-99m MIBI，觀察放射藥物靜脈注射後一開始流過心臟右心室到肺臟，再進入左心室後進入主動脈的過程，可以計算右心室和左心室的射出分率 (ejection fraction, EF)，是評估右心室功能的最佳工具。[16] 方法與步驟: ①檢查準備事項: 影響檢查的藥劑必須於檢查前一天停用，如乙型阻斷劑、鈣離子阻斷劑及含有 aminophylline 或 theophylline 的藥劑或食品。檢查當天須停止服用高血壓及心臟用藥。含咖啡因之食物、飲料應停止食用至少一天以上。②放射製劑種類與劑量:10 - 20 mCi 的 Tc-99m-Sestamibi (Tc-99m MIBI)經右側手臂或頸靜脈注射。③儀器造影條件: 準直儀：低能量高敏感度(low energy high sensitivity)或全能 (all-purpose)準直儀。能階能窗：140 KeV ± 10%，影像矩陣大小(matrix size)：64 x 64 像素(pixel)，放大倍數：2.0 倍。掃描時間或計數： 0.05 秒/張畫面(frame) 共收錄 440 張畫面。④檢查步驟: a.協助受檢者仰躺於注射床，去除受檢者身上會影響檢查之物品。b.於受檢者身上貼置心電圖電極片。c.量測病人血壓值，若受檢者血壓過高則必須評估是否合適於運動。d.在右側手臂或頸靜脈建立留置針注射套組，以方便運動達標時注射藥物的血管。e.輸入受檢者基本資料，並記錄受檢者的心電圖。f.讓受檢者運動，達標或達到受檢者可運動的生理極限時，立即移置核醫造影檢查檯平躺。g. 攝影機探頭呈右前斜位 30 度，以彈丸式注射(bolus injection)進行放射核種第一次穿流心臟血管攝影。h.右前斜位 30～45°，注射 Tc-99m MIBI 前 2 秒即開始收取影像影，以確保能收錄到放射藥物流經右心室的影像。⑤影像處理與分析步驟: a.將影像依序列顯示於螢幕上，確認照野與左右標記並有顯示灰階表(gray scale)。b.選取右心室與左心室出現最適當時間影像，分別選取右心室與左心室關心區(region of interests, ROIs)，得出右心室與左心室的各別時間-活度曲線(time-activity curves) (圖二)。c.選取收縮末期的(end-systolic)與舒張末期的(end diastolic)時間點放射活性，以計算右心室與左心室的各別射出分率(ejection fraction, EF)。

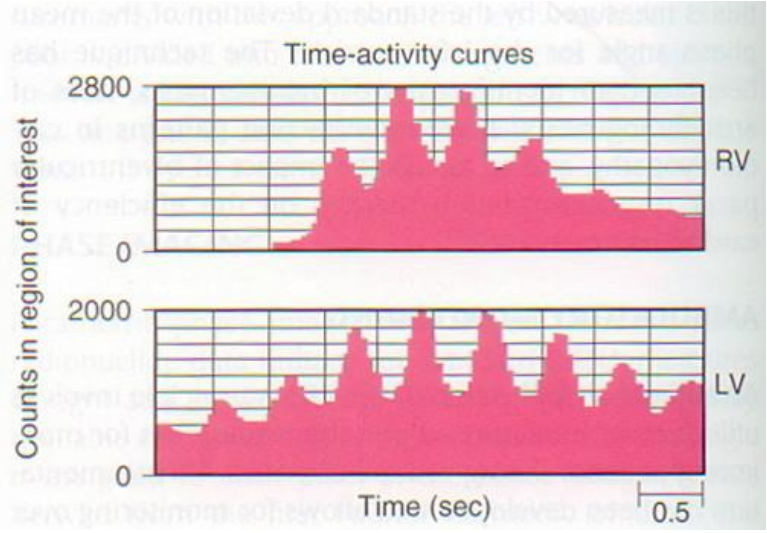


Figure 2.放射核種第一次穿流心臟血管攝影影像中選取右心室與左心室關心區(region of interests, ROIs)，所獲得出的右心室與左心室的各別時間-活度曲線(time-activity curves)。每一組波峰(peak)與波谷(valley)分別代表舒張末期(end diastolic)與收縮末期(end-systolic)的放射活性，每一組波峰與波谷代表一個心跳的血循環變化。經選取較具代表性的 2 或 3 個心跳的血循環變化，以計算右心室與左心室的各別射出分率(ejection fraction, EF)。[16]

統計方法: Data were summarized as mean ± standard deviation. For each outcome variable, the comparisons were planned a priori. In univariate analysis, p values were calculated by ANOVA with Tukey's correction for multiple comparisons to compare means across the three groups. The unpaired t test was used to compare two samples. Fisher's exact method was used in contingency table analysis for categorical variables. Pearson's correlation coefficients were used to quantify the pair-wise relationships between interested variables. All statistical analyses were performed using SAS statistical software. Statistical significance was set at $p < 0.05$.

四、結果

共篩選 190 位，進入分析 82 位(含嘉義長庚 COPD 13 位)，其中，正常組 34 位，COPD 組 31 位，CHF 組 17 位 (Figure 3)。

三組比較，CHF 組較年輕，體重指數較高。COPD 組的抽菸包-年較大、COPD 症狀綜合指數較高。正常組的日常體力指數較高、活動性喘、休息時喘、心衰症狀指數等等的分數較低 (Table 1)。CHF 組的血紅素、GPT、NT proBNP、血糖較高，COPD 組的 CRP 較高，正常組的 WBC 較低。

比較三組的肺功能，COPD 所有肺功能皆較差，僅 TLC 無統計方面的差異 (Table 2)。

比較三組的運動心肺功能，在休息時，CHF 的 O_2P 與舒張壓較高，COPD 的 V_E/VCO_2 及呼吸頻率較高、呼吸儲備量及 S_PO_2 較低 (Table 3A)。在空踩的時候，與休息時類似。在負荷運動達無氧閾值時，CHF 組的舒張壓較高。COPD 組的負荷力度、VCO_2、O_2P、S_PO_2、呼吸儲備量皆較低，V_E/VO_2、V_E/VCO_2、EELV

較高。正常人的心率較高 (Table 3B)。在負荷運動達峰值時，CHF 的收縮壓較低、舒張壓較高。COPD 的負荷力度、VCO_2、O_2P、S_PO_2、換氣量、呼吸儲備量、潮氣容積、潮氣容積/TLC 皆較低，EELV、EELV/TLC 則較高。正常人的 VO_2%、心率、呼吸頻率較高。

在負荷運動時的 O_2P 型態，CHF 組 17 位，上升型 1 位、高原型 8 位、下降型 5 位、無法歸類 3 位(Table 3C)。COPD 組 31 位，上升型 11 位、高原型 17 位、下降型 1 位、無法歸類 2 位。正常組 34 位，上升型 16 位、高原型 12 位、下降型 4 位、無法歸類 2 位。三組 O_2P 型態有整體上的差異(Table 3C, overall Fisher's exact test $p = 0.01$)，主要是因為 CHF 組上升型最少(CHF 組: COPD 組:正常組= 6%:35%:47%)，下降型最多(29%:3%:12%)，無法分類型也最多(18%:6%:6%)。

比較三組的心臟超音波(Table 4)，CHF 組在收縮期與舒張期的 LV 與 LA 的 diameter、質量較大、流速較慢、EF 較低。正常組的二尖瓣 E/A、主動脈瓣面積較大。比較三組的第一穿流核醫攝影(Table 4)，COPD 組的 RVEF 較高，CHF 組的 LVEF 較低。

五.討論（含建議）

O_2P study 預計兩年收案 200 例，但經費只有一年，故只能以收案 100 例計算，達成率 82% (Figure 3)。CHF 個案偏少，可能與國內 CV 醫師較少安排運動心肺功能測試有關。

CHF 個案的年齡較輕、體重指數較高，造成 selection 偏差。這需要且可以用 population base 的資料或體重加以校正。COPD 組抽菸的包·年較大，顯然與 COPD 致病有關，COPD 症狀問卷的綜合指數較高，代表此問卷適合 COPD 者，且足以區分其他病況。而 COPD 組與 CHF 組的 OCD、mMRC 與 NYHAFc 的分數，兩組無差異，顯然不同的心肺病可造成相似的體能及日常活動的限制；或者也可解釋為這些量表辨識力不足。

CHF 個案的血紅素較高，可能受年齡與體重的影響($r = -0.37$ and 0.3, $p = 0.0007$ and 0.0064)。正常組的 WBC 較低，CHF 的血糖較高，臨床意義不明。血糖與體重無相關($r = 0.04$, $p = NS$)。COPD 的嗜伊紅性 WBC 未比較高，CRP 則較高，是否 COPD 即使在臨床穩定時仍有低度發炎，值得關切。但進一步分析，主要是機構效應(中山與嘉長比較 0.26 ± 0.24 vs. 4.71 ± 5.25, $p = 0.001$)。

肺功能異常是 COPD 的特色，肺功能足以區分 COPD 於正常與 CHF 者。當然，MIP/MEP 或呼吸肌肉氧合能力在 CHF 也有異常的文獻報告[17]，只是未用於本研究。更嚴重的 CHF 也有低 FVC、D_LCO 的報告。

運動心肺功能儀顯示其解析度極佳，即使休息時也可以鑑別心肺病。在休息時 CHF 的 O_2P、舒張壓比較高，是否表示即使在休息之下，CHF 心臟的負荷已比較大了。呼吸異常顯然是 COPD 的特色，呈現比較明顯的過度換氣、呼吸頻率快、呼吸儲備量低、肺殘氣(EELV)多、S_PO_2 低。這些差異可以持續到運動逐漸到達無氧閾值時。

當運動達到峰值時，CHF 獨特地收縮壓較低，顯然心臟已無法負荷高力度運動，反到是 O_2P 並未比 COPD 低，甚至與正常者相似，這實在是挑戰了 O_2P 足以代表心臟 stroke volume 的傳統說法。但 O_2P 受年齡、體重血紅素的影響，是主因(r = -0.49, 0.47 and 0.41, p 前兩者<0.0001, 後者 0.0055)。休息時作的心臟超音波定量的 ejection fraction，亦無法反應 O_2P (r=0.04, p = NS)。O_2P 代表心臟 stroke volume 是建立在周邊肌肉對氧氣吸收的量是定值這一個概念，即在休息、運動到無氧閾值或峰值時，各是 5、10、15 mL/100 mL 動脈血 [18]，故只要周邊肌肉沒有原發性病變，COPD、CHF、正常人的肌肉對氧氣吸收的量視為皆然。然而近年，周邊肌肉對氧氣吸收的量已發現不是這樣 [19,20]，特別是 COPD[20] 與 CHF[19]，因此 O_2P 與 stroke volume 的關係不應如此緊密，甚至難以估計。

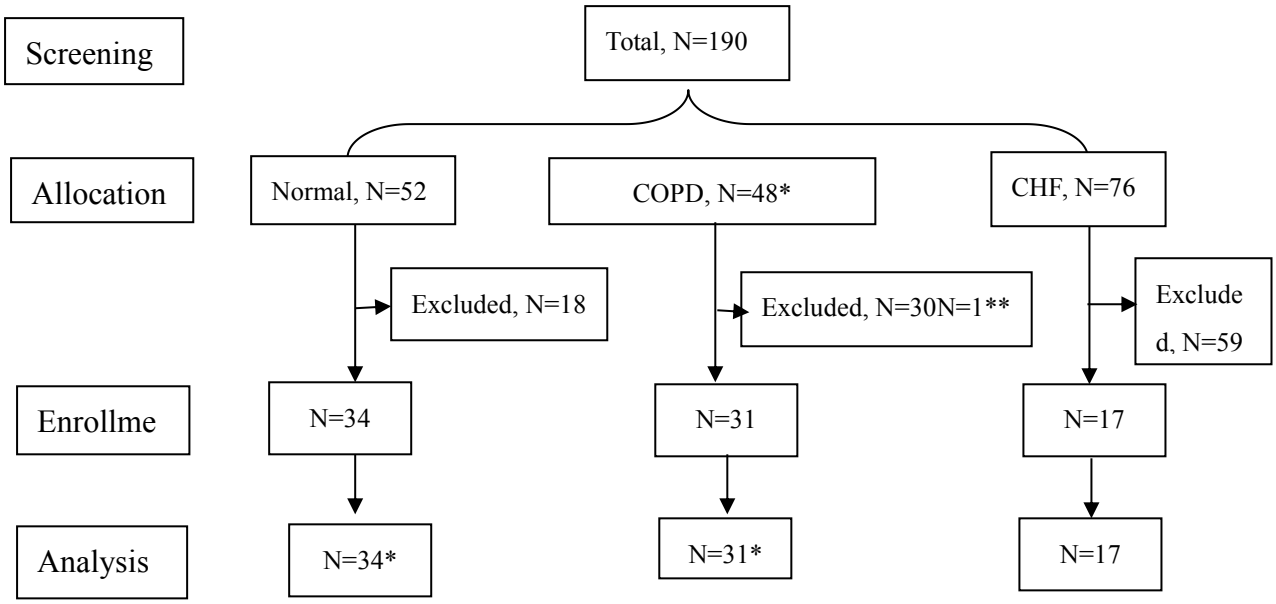
由 O_2P 型態的研究可得知，O_2P 的型態可以區分此三組人，意即 CHF 者不太可能為上升型，反到是下降型比較有可能。反觀 O_2P 的值(即使採%預測值做校正)，無法區分此三組參與者。值得注意的是，正常人也有下降型，這似乎產生困擾。但，正常人的運動最大攝氧量(採%預測值)為正常，足以區分 CHF。幸運的是，COPD 組很少有下降型。

綜合以上(Figure 4)，下降型則尚需結合最大攝氧量%預測值，若亦下降，則為 CHF 的可能性大增。此情況不是只有正常人不會如此，COPD 者亦不會如此，因為 COPD 鮮少 O_2P 為下降型。

至於 COPD，仍然以肺部異常的機制表現，尤其是運動肺殘氣更加高張，造成潮氣容積擴張需極力地將吸氣肌與肺彈性纖維拉撐 [21]，加上呼吸換氣能力減低與肺死腔無法有效降低 [22]，因而達到呼吸極限、血氧飽和度降低，而最後必須停止運動，因此運動力度低。

心臟超音波呈現 CHF 不只是 ejection fraction 比較低，LV、LA、質量也比較大。這些異常是 CHF 的特色，但無法反應在運動心肺功能上，只有收縮壓與舒張壓可以。CHF 心臟超音波與第一穿流核醫攝影的 LVEF 是一致的(r = 0.59, p < 0.0001)。顯然這兩種診斷工具同屬可以診斷心臟功能，但卻與 O_2P 大相逕庭，是否因心臟功能差而使周邊肌肉對氧氣吸收的量有代償作用，仍需日後的研究。

Figure 3. Flow Diagram.



*含長庚 N=14, **含長庚 N=1

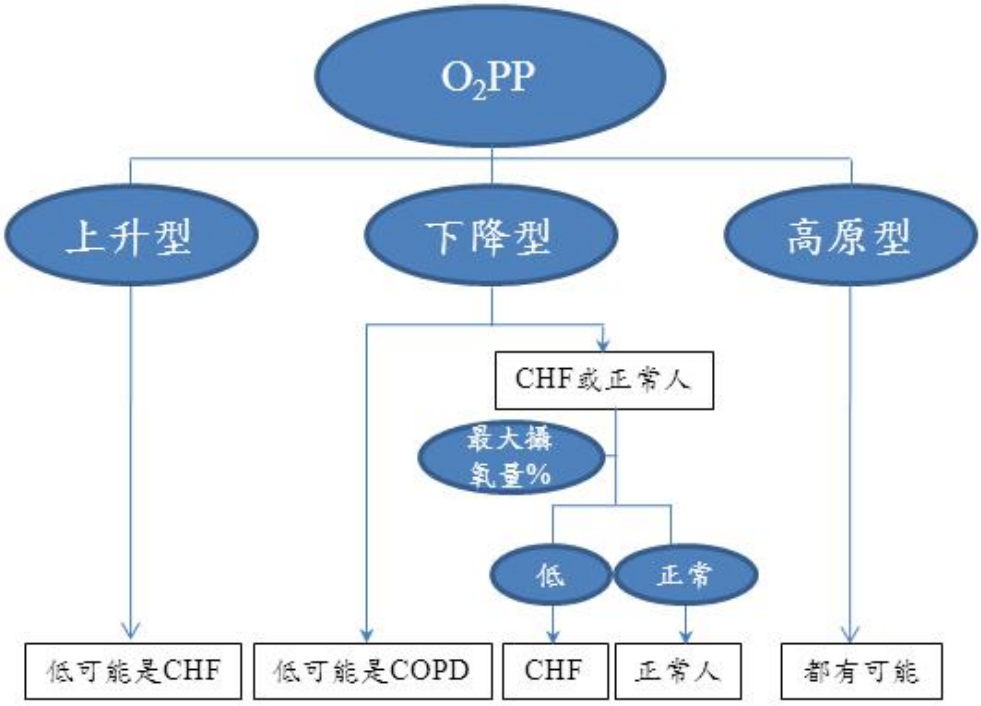


Figure 4. Flowchart of O_2 pulse patterns (O_2PP). Ovoid shape indicates exercise data. Arrow indicates diagnosis.

Table 1. Demographic data , symptom scores and blood tests.

	Norm		COPD		CHF		ANOVA
	mean	SD	mean	SD	mean	SD	p value
n =	34		31		17		
Age, year	62.2	9.2	68.4	7.4	**57.3**	8.4	0.0001
Height, cm	167.0	5.3	165.5	5.4	167.4	5.0	NS
Weight, kg	69.2	8.9	63.3	10.0	**76.6**	10.0	<0.0001
BMI, kg/m^2	24.77	2.66	23.00	3.17	**27.3**	3.2	<0.0001
Cigarette, pack·yr	5.2	17.7	**66.6**	38.8	30.7	28.7	<0.0001
CAT sum	0.5	1.0	**5.9**	6.8	3.7	3.6	<0.0001
OCD, cm	**8.3**	1.0	7.0	1.6	7.7	0.9	0.0004
mMRC (0-4)	0.0	0.0	**0.7**	0.7	0.3	0.5	<0.0001
Borg score at rest	**0.03**	0.2	0.3	0.5	0.4	0.4	0.005
NYHAFc	**1.0***	0.0	1.7	0.7	1.5	0.5	<0.0001
RBC, 10^4/uL	481.5	41.0	493.8	62.3	503.4$^{\$\$}$	29.4	NS
Hb, g/dL	14.7	1.2	14.8	1.6	**15.8**$^{\$\$}$	0.9	0.02
WBC, /uL	**6185.3**	1250.6	7032.3	1303.4$^{\$\$}$	7695$^{\$\$}$	1332.8	0.0006
Segment, %	57.5**	8.7	61.7^{+}	10.0$^{\$}$	62.8$^{\$}$	8.4	NS
Lymph, %	32.7**	8.9	27.5^{+}	8.6	26.5$^{\$}$	7.8	0.06
Monocyte, %	6.8 **	1.4	6.8 $^{+}$	1.8	6.8$^{\$}$	1.4	NS
Eosinophil, %	2.4**	1.3	3.7^{+}	2.6	2.7$^{\$}$	1.9	NS
Basophil, %	0.6**	0.2	0.7^{+}	0.3	0.6$^{\$}$	0.3	NS
Platelet, 10^3/uL	234.3	59.2	221.4	48.0	249.3$^{\$\$}$	63.1	NS
Creatinine, mg/dL	1.0	0.3	1.0^{++}	0.2	1.1$^{\$\$}$	0.2	NS
Na, mmol/L	138.4	2.2	139.5^{++}	3.3	137.9 ‘	2.4	NS
K, mmol/L	4.1	0.4	4.1^{++}	0.4	4.1$^{\$\$}$	0.5	NS
GPT, IU/L	28.1	10.9	21.0^{++}	10.2	**31.4**$^{\$\$}$	14.5	0.02
Bil-T, mg/dL	0.85	0.39	0.76$^{\#}$	0.29	0.76$^{\$\$}$	0.26	NS
CRP, mg/dL	0.16	0.23	2.04^{++}	**3.93**	0.26 ‘	0.35	0.007
NT proBNP, pg/mL	47.8	38.5	46.0^{++}	35.4	**312.6**$^{\$\$\$}$	320.5	<0.0001
Glucose (PC), mg/dL	110.8	24.0	112.7$^{\#\#}$	24.4	**147.6**$^{\$\$}$	81.9	0.01

BMI: body mass index, OCD: oxygen cost diagram, mMRC: modified medical research council, CAT: COPD assessment test, NYHAFc: New York heart association functional class, Bil-T: bilirubin total, CRP: C-reactive protein, NT proBNP: N-terminal pro-brain natriuretic peptide . n = *33, **23; $^{+}$20; $^{++}$30; $^{\#}$28, $^{\#\#}$27, $^{\$}$12, $^{\$\$}$16, $^{\$\$\$}$14, ‘15

Table 2. Lung function test.

	Norm		COPD		CHF		ANOVA
	Mean,	SD	Mean,	SD	Mean,	SD	P value
n=	34		31		16		
FVC, %p	101.4	12.7	78.5	13.0	92.7	10.1	<0.0001
FEV_1, %p	102.5	12.6	61.1	15.3	93.1	10.2	<0.0001
FEV_1/FVC	79.9	5.6	57.4	10.2	80.3	3.5	<0.0001
$MMEF_{75/25}$, %p	92.9	28.3	27.6	10.8	85	22.8	<0.0001
PEF, %p	104.1	18.0	60.3*	23.4	82.1	14.7	<0.0001
IC forced, %p	104.3	18.4	73.2	17.6	101.2**	15.2	<0.0001
TLC%p	96.9	10.6	98.9	11.5	91.5	5.9	0.07
RV%p	100.9	17.2	140.4	33.7	98.2	14.1	<0.0001
RV/TLC	38.8	6.4	56.4	10.4	38.3	7.9	<0.0001
RV/TLC%p	101.4	11.7	138.5	21.9	104.6	15.3	<0.0001
FRC_{pleth}%p	95.6	16.1	121.8	23.4	87	10.8	<0.0001
D_LCO_{SB}%p	105.6	15.6	76.6	20.1	89.7	12.7	<0.0001
D_LCO/V_A%p	103.3	15.9	74.7	20.5	103.5	11.7	<0.0001
V_A%p	86.3	11.3	71.1*	12.1	79.1	10.4	<0.0001

n =* 18, **15

Table 3A. Cardiopulmonary exercise test at rest and unloding exercise.

	Norm		COPD		CHF		ANOVA
	mean	SD	mean	SD	mean	SD	P value
N =	34		31		17		
VO_2/kg-rest mL/min/kg	4.2	1.3	4.49	1.33	4.6	1.1	NS
HR-rest 1/min	78.2	12.3	78.2	12.8	77.9	13.4	NS
O_2/HR-rest mL	3.7	1.1	3.67	1.17	**4.6**	1.3	0.03
BPsys-rest mmHg	141.1	20.8	145.9*	25.7	141.5	20.5	NS
BPdia-rest mmHg	85.7	13.5	83.0*	14.1	**95.2**	15.8	0.02
VE/VO_2_rest	36.5	11.4	40.0	9.0	33.0	6.3	0.06
VE/VCO_2_rest	42.3	7.8	**46.5****	7.1	39.6	6.4	0.006
SpO_2_rest %	97.2	1.2	**96.2**	1.9	97.2	1.1	0.009
V'_E_rest L/min	11.3	4.3	12.4	3.6	12.4	3.1	NS
$V_T$ex_rest L	0.81	0.46	0.74	0.35	0.81	0.24	NS
BF_rest 1/min	15.0	4.5	**18.2**	4.6	16.5	5.8	0.03
BR_rest %	90.1	3.6	**76.9**	9.0	88.3	3.9	<0.0001
EELV_rst	2.95 $^{+}$	0.98	3.57 $^{\$\$}$	0.86	2.82 $^{\#\#}$	0.79	0.07
EELV_rst/TLC	0.48 $^{+}$	0.13	**0.60** $^{++}$	0.11	0.48 $^{\#}$	0.13	0.02
VO2/kg-un mL/min/kg	7.7	1.8	8.0	2.1	8.1	1.9	NS
HR-un 1/min	86.1	13.3	84.6	11.8	85.1	12.6	NS
O2/HR-un mL	6.2	1.4	6.0	1.4	**7.1**	1.6	0.03
BPsys-un mmHg	146.5	21.5	148.9*	20.7	145.5	21.7	NS
BPdia-un mmHg	87.1	12.8	83.9*	13.9	**97.9**	20.7	0.01
V_E/VO_2_un	30.0	5.2	**36.6**	7.6	29.8	5.7	<0.0001
V_E/VCO_2_un	36.5	4.2	**43.6**	7.2	36.3	4.4	<0.0001
SpO2_un, %	97.4	1.0	**95.6**	2.0	97.0	1.2	<0.0001
V'_E_un, L/min	**17.0**	3.9	19.5	4.6	19.5	5.4	0.05
VTex_un, L	0.94	0.29	0.97	0.23	1.07	0.46	NS
BF_un, 1/min	19.0	4.6	20.3	3.9	19.7	5.3	NS
BR_un, %	84.9	4.8	**63.0**	14.6	81.7	6.6	<0.0001
EELV_un, L	2.72*	0.92	**3.71** $^{\#\#}$	0.91	2.73 $^{\$}$	0.66	0.001
EELV_un/TLC	0.45*	0.13	**0.61** $^{\#\#}$	0.12	0.48 $^{\$}$	0.12	0.0007

n = *29, **30, $^{+}$21; $^{++}$12, $^{\#}$14, $^{\#\#}$15, $^{\$}$16, $^{\$\$}$13, $^{\$\$\$}$28

Table 3B. Cardiopulmonary exercise test at anaerobic threshold (AT) and peak exercise.

	Norm		COPD		CHF		ANOVA
	mean	SD	mean	SD	mean	SD	P value
N =	34		31		17		
Load_AT, watts	77.6	28.0	**50.2***	21.1	64.5	11.5	<0.0001
VO_2/kg- AT, mL/min/kg	14.9	4.3	12.7*	3.3	13.2	2.7	0.06
VO_2%p_AT, %	53.0	11.8	47.9*	12.6	47.4	8.9	NS
V'CO_2-AT, mL/min	908.8	290.7	**691.8***	217.4	837.4	208.3	0.006
HR_AT, 1/min	**108.7**	13.8	96.8*	14.1	99.6	13.2	0.003
VO_2/HR_AT, mL	9.3	2.1	**8.4***	2.1	10.1	1.7	0.02
BPsys_AT, mm Hg	165.7	24.0	165.2**	26.2	153.9	24.3	NS
BPdia_AT, mm Hg	88.2	19.7	84.8**	14.8	**101.4**	19.0	0.01
V_E/VO_2_AT	28.2	3.9	**33.1***	6.4	26.9	4.4	<0.0001
V_E/VCO_2_AT	31.7	3.6	**38.4***	6.6	32.2	3.7	<0.0001
SpO_2_AT, %	97.1	1.1	**93.4***	9.6	96.6	1.3	0.04
V'$_E$_AT, L/min	29.8	6.8	27.7*	6.1	28.4	6.5	NS
$V_T$ex_AT, L	1.43	0.50	1.26*	0.30	1.46	0.71	NS
EELV_AT, L	2.66*	0.86	**3.45**$^{\#}$	0.73	2.87	0.78	0.01
EELV_AT/TLC	0.44*	0.13	**0.58**$^{\#}$	0.12	0.49$^{\#\#}$	0.14	0.005
BF_AT, 1/min	22.0	4.6	22.2*	3.3	21.2	5.4	NS
BR-AT, %	74.3	6.1	**50.0***	16.2	73.7	7.0	<0.0001
Load-pk, watts	146.6	34.7	**93.3**	38.9	125.4	26.8	<0.0001
VO_2/kg-pk, mL/min/kg	**25.5**	6.8	19.2	5.5	20.3	5.0	0.0002
VO_2%p-pk, %	**90.7**	19.4	71.7	19.1	73.3	18.9	0.0003
V'CO_2-pk, mL/min	1984.9	526.8	**1234.9**	482.5	1626.5	435.1	<0.0001
HR-pk, 1/min	**149.4**	16.8	124.9	20.8	135.2	22.9	<0.0001
O_2/HR-pk, mL	11.5	2.5	**9.6**	2.5	11.4	2.0	0.007
BPsys-pk, mmHg	207.4	25.2	201.4+	36.2	**178.8**	23.7	0.006
BPdia-pk mmHg	101.6	24.9	94.0+	20.5	**113.8**	21.1	0.02
Borg-leg-pk	6.5	2.1	5.9^{++}	2.5	7.1	2.6	NS
Borg-SOB-pk	5.8	2.2	6.2^{++}	2.8	5.8	2.4	NS
V_E/VO_2-pk	39.7	7.6	37.4++	8.6	35.8	6.8	NS
V_E/VCO_2-pk	34.5	5.0	37.5++	7.9	33.9	5.2	0.08
SpO_2-pk, %	96.8$^{\$}$	1.2	**91.8** $^{+}$	7.1	96.5	1.7	0.01
V'$_E$-pk L/min	70.4	18.0	**46.8**	15.7	56.4	15.4	<0.0001
$V_T$ex-pk L	1.96	0.42	**1.43**	0.35	1.84	0.41	<0.0001
$V_T$pk/TLC	0.32	0.05	**0.24**	0.06	0.32$^{\#\#}$	0.08	<0.0001

EELV_pk		2.77**	0.88	**3.80**$^{++}$	0.85	3.00	0.53	0.0003
EELV_pk/TLC		0.46**	0.13	**0.63**$^{++}$	0.11	0.51$^{\#\#}$	0.07	<0.0001
BF-pk	1/min	**36.6**	9.3	32.6	6.6	31.5	8.2	0.05
BR-pk	%	39.8	13.4	**18.8**	14.7	48.1	15.6	<0.0001

N=*29, **28, $^{+}$30, $^{++}$17, $^{\#}$15, $^{\#\#}$16, $^{\$}$33

Table 3C. O_2 pulse patterns at peak exercise.

	Normal	COPD	CHF
n =	34	31	17
Increasing	16 (47%)	11 (35%)	1 (6%)
Plateau	12 (35%)	17 (55%)	8 (47%)
Decreasing	4 (12%)	1 (3%)	5 (29%)
Unclassified	2 (6%)	2 (6%)	3 (18%)

Fisher's exact test was performed. Overall p = 0.01, normal versus COPD, p = 0.19, normal versus CHF, p = 0.01, COPD versus CHF, p = 0.006.

Table 4. Echocardiography and nuclear scintigraphy.

	Norm		COPD		CHF		ANOVA
	mean	SD	mean	SD	mean	SD	P value
N =	8		30		17		
LVIDs, cm	3.18	0.21	3.16^{+}	0.30	**4.29**	0.69	<0.0001
LVIDd, cm	4.8	0.3	4.8^{+}	0.5	**5.4**	0.7	0.002
LVPWs, cm	1.51	0.21	1.39**	0.16	1.42	0.13	NS
LVPWd, cm	1.0	0.2	1.0	0.2	1.0	0.13	NS
LVOTD, cm	2.26	0.19	2.15**	0.14	2.28	0.16	0.07
LVOT_mx, cm/s	97.8	11.8	95.3**	26.4	**74.4**	20.3	0.01
LV_mass, g	183.8	55.0	150.8$^{\#\#}$	27.8	**217.7**$^{\$}$	71.5	0.0005
EF_T, %	61.3	5.9	64.3	10.9	**43.4**	8.3	<0.0001
IVSs, cm	1.42	0.16	1.29**	0.14	1.33	0.14	NS
IVSd, cm	1.1	0.2	1.1	0.5	1.0	0.1	NS
LAD, cm	3.7	0.4	3.6	0.6	4.1	0.7	0.045
RA_p. mmHg	7.5	2.7	8.8**	2.8	8.8	3.3	NS
MV A, cm/s	76.9	16.1	90.0**	15.8	87.1$^{\$}$	17.1	NS
MV E, cm/s	72.7	14.1	61.4**	12.6	69.6	23.1	NS
MV E/A	**0.99**	0.28	0.68**	0.15	0.77$^{\$}$	0.25	0.01
AoRD, cm	3.29	0.26	3.40	1.31	3.19	0.26	NS
ACS, cm	1.59	0.29	1.41**	0.29	1.55	0.32	NS
AV_max, cm/s	124.0	21.3	132.6	31.4	132.3	63.1	NS
AVmaxPG, mmHg	6.3	2.5	7.5	3.5	8.6	12.1	NS
AVA, cm^2	**3.2**	0.7	2.4**	0.6	2.4	0.7	0.009
Max vel_TR, cm/s	227.88	37.03	243.96^{++}	34.71	249.76	40.07	NS
Max PG_TR, mmHg	21.3	5.9	25.8**	5.4	25.9	9.3	NS
RVSP(TR), mmHg	28.8	7.8	34.6**	6.5	34.4	11.5	NS
PA_Vmax, cm/s	89.6*	16.8	77.8 $^{\#}$	39.1	85.1	23.2	NS
RVEF,%	57.4	12.9	**63.2**	13.2	52.3***	7.4	0.02
LVEF,%	72.4	3.6	62.8	12.3	**43.5****	12.4	<0.0001

n = *7, **17; ***15, $^{+}$22; $^{++}$25; $^{\#}$20, $^{\#\#}$26, $^{\$}$16

Appendix:

European Heart Journal 2008; doi:10.1093/eurheartj/ehn309

Table 3 Definition of heart failure

Heart failure is a clinical syndrome in which patients have the following features:

- **Symptoms typical of heart failure**
  (breathlessness at rest or on exercise, fatigue, tiredness, ankle swelling)

  and
- **Signs typical of heart failure**
  (tachycardia, tachypnoea, pulmonary rales, pleural effusion, raised jugular venous pressure, peripheral oedema, hepatomegaly)

  and
- **Objective evidence of a structural or functional abnormality of the heart at rest**
  (cardiomegaly, third heart sound, cardiac murmurs, abnormality on the echocardiogram, raised natriuretic peptide concentration)

Table 5 Classification of heart failure

• **New onset**	First presentation Acute or slow onset
• **Transient**	Recurrent or episodic
• **Chronic**	Persistent Stable, worsening, or decompensated

Table 6 Classification of heart failure by structural abnormality (ACC/AHA), or by symptoms relating to functional capacity (NYHA)

ACC/AHA stages of heart failure		NYHA functional classification	
Stage of heart failure based on structure and damage to heart muscle		**Severity based on symptoms and physical activity**	
Stage A	At high risk for developing heart failure. No identified structural or functional abnormality; no signs or symptoms.	**Class I**	No limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, or dyspnoea.
Stage B	Developed structural heart disease that is strongly associated with the development of heart failure, but without signs or symptoms.	**Class II**	Slight limitation of physical activity. Comfortable at rest, but ordinary physical activity results in fatigue, palpitation, or dyspnoea.
Stage C	Symptomatic heart failure associated with underlying structural heart disease.	**Class III**	Marked limitation of physical activity. Comfortable at rest, but less than ordinary activity results in fatigue, palpitation, or dyspnoea.
Stage D	Advanced structural heart disease and marked symptoms of heart failure at rest despite maximal medical therapy.	**Class IV**	Unable to carry on any physical activity without discomfort. Symptoms at rest. If any physical activity is undertaken, discomfort is increased.

ACC = American College of Cardiology; AHA = American Heart Association. Hunt SA *et al*. *Circulation* 2005;**112**:1825–1852.
The Criteria Committee of the New York Heart Association. Nomenclature and Criteria for Diagnosis of Diseases of the Heart and Great Vessels. 9th ed. Little Brown & Co; 1994. pp 253–256.

Table 7 Common causes of heart failure due to disease of heart muscle (myocardial disease)

Coronary heart disease	Many manifestations
Hypertension	Often associated with left ventricular hypertrophy and preserved ejection fraction
Cardiomyopathies*	Familial/genetic or non-familial/non-genetic (including acquired, e.g. myocarditis)
	Hypertrophic (HCM), dilated (DCM), restrictive (RCM), arrhythmogenic right ventricular (ARVC), unclassified
Drugs	β-Blockers, calcium antagonists, antiarrhythmics, cytotoxic agents
Toxins	Alcohol, medication, cocaine, trace elements (mercury, cobalt, arsenic)
Endocrine	Diabetes mellitus, hypo/hyperthyroidism, Cushing syndrome, adrenal insufficiency, excessive growth hormone, phaeochromocytoma
Nutritional	Deficiency of thiamine, selenium, carnitine. Obesity, cachexia
Infiltrative	Sarcoidosis, amyloidosis, haemochromatosis, connective tissue disease
Others	Chagas' disease, HIV infection, peripartum cardiomyopathy, end-stage renal failure

*See text for details.

Table 15 Common echocardiographic abnormalities in heart failure

Measurement	Abnormality	Clinical implications
LV ejection fraction	Reduced (<45–50%)	Systolic dysfunction
LV function, global and focal	Akinesis, hypokinesis, dyskinesis	Myocardial infarction/ischaemia Cardiomyopathy, myocarditis
End-diastolic diameter	Increased (>55–60 mm)	Volume overload HF likely
End-systolic diameter	Increased (>45 mm)	Volume overload HF likely
Fractional shortening	Reduced (<25%)	Systolic dysfunction
Left atrial size	Increased (>40 mm)	Increased filling pressures Mitral valve dysfunction Atrial fibrillation
Left ventricular thickness	Hypertrophy (>11–12 mm)	Hypertension, aortic stenosis, hypertrophic cardiomyopathy
Valvular structure and function	Valvular stenosis or regurgitation (especially aortic stenosis and mitral insufficiency)	May be primary cause of HF or complicating factor Assess gradients and regurgitant fraction Assess haemodynamic consequences Consider surgery
Mitral diastolic flow profile	Abnormalities of the early and late diastolic filling patterns	Indicates diastolic dysfunction and suggests mechanism
Tricuspid regurgitation peak velocity	Increased (>3 m/s)	Increased right ventricular systolic pressure Suspect pulmonary hypertension
Pericardium	Effusion, haemopericardium, thickening	Consider tamponade, uraemia, malignancy, systemic disease, acute or chronic pericarditis, constrictive pericarditis
Aortic outflow velocity time integral	Reduced (<15 cm)	Reduced low stroke volume
Inferior vena cava	Dilated Retrograde flow	Increased right atrial pressures Right ventricular dysfunction Hepatic congestion

Table 16 Doppler-echocardiographic indices and ventricular filling

Doppler indices	Pattern	Consequence
E/A waves ratio	Restrictive (>2, short deceleration time <115 to 150 ms)	High filling pressures Volume overload
	Slowed relaxation (<1)	Normal filling pressures Poor compliance
	Normal (>1)	Inconclusive as may be pseudo-normal
E/Ea	Increased (>15)	High filling pressures
	Reduced (<8)	Low filling pressures
	Intermediate (8–15)	Inconclusive
(A mitral–A pulm) duration	>30 ms	Normal filling pressures
	<30 ms	High filling pressures
Pulmonary S wave	>D wave	Low filling pressures
Vp	<45 cm/s	Slow relaxation
E/Vp	>2.5	High filling pressures
	<2	Low filling pressures
Valsalva manoeuvre	Change of the pseudonormal to abnormal filling pattern	Unmasks high filling pressure in the setting of systolic and diastolic dysfunction

六、文獻探討

References:

1. Wasserman K, Hansen JE, Sue DY, Stringer WW, Whipp BJ. Physiology of exercise. In: Wasserman K, ed. *Principles of exercise testing and interpretation*. 4th ed. Philadelphia: Lippicott Williams & Wilkins; 2005:10-65.
2. Munhoz EC, Hollanda R, Vargas JP, et al. Flattening of oxygen pulse during exercise may detect extensive myocardial ischemia. *Med Sci Sports Exerc.* 2007;39(8):1221-1226.
3. Chuang ML, Lin IF, Huang SF, Hsieh MJ. Patterns of Oxygen Pulse Curve in Response to Incremental Exercise in Patients with Chronic Obstructive Pulmonary Disease - An Observational Study. *Sci Rep.* 2017;7(1):10929.
4. Belardinelli R, Lacalaprice F, Carle F, et al. Exercise-induced myocardial ischaemia detected by cardiopulmonary exercise testing. *Eur Heart J.* 2003;24(14):1304-1313.
5. GOLD Committees. Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease (revised 2015). *Disclosure forms for GOLD Committees are posted on the GOLD Website, www.goldcopd.org*. 2017.
6. Dickstein K, Cohen-Solal A, Filippatos G, et al. ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2008 The Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2008 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association of the ESC (HFA) and endorsed by the European Society of Intensive Care Medicine (ESICM). *Europ Heart J.* 2008;29(19):2388-2442.
7. James PA, Oparil S, Carter BL, et al. 2014 evidence-based guideline for the management of high blood pressure in adults. report from the panel members appointed to the Eighth Joint National Committee (JNC 8). . *JAMA* 2014;311(5):507-520. .
8. Le Jemtel TH, Padeletti M, Jelic S. Diagnostic and therapeutic challenges in patients with coexistent chronic obstructive pulmonary disease and chronic heart failure. *J Am Coll Cardiol* 2007;49:171–180.
9. Miller MR, Hankinson J, Brusasco V, et al. Standardisation of spirometry. *Eur Respir J.* 2005;26(2):319-338.
10. Macintyre N, Crapo RO, Viegi G, et al. Standardisation of the single-breath determination of carbon monoxide uptake in the lung. *Eur Respir J.* 2005;26(4):720-735.
11. Wasserman K, Hansen JE, Sue DY, Stringer WW, Whipp BJ. Clinical exercise

testing. In: Wasserman K, ed. *Principles of exercise testing and interpretation*. 4th ed. Philadelphia: Lippicott Williams & Wilkins; 2005:133-159.

12. Bertoli L, Mantero A, Cicero SL, Alpago R, Rizzato G, Belli C. Usefulness of two-dimentional echocardiography in the assessment of right heart in chronic obstructive lung disease. *Progress in Respiration Research.* Vol 20. Basel: Karger; 1985:91-100.
13. Danchin N, Cornette A, Henriquez A, et al. Two-dimensional echocardiographic assessment of the right ventricle in patients with chronic obstructive lung disease. *Chest.* 1987;92(2):229-233.
14. Lang RM, Badano LP, Mor-Avi V, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American society of echocardiography and the european association of cardiovascular imaging. *Eur Heart J.* 2015;16:233-271.
15. Chuang ML, Lee CH, Lin IF. Using the oxygen-cost diagram in ramp-slope selection for dyspneic patients. *Intern Med.* 2010;49(14):1325-1332.
16. Zaret BL, Beller GA. Clinical Nuclear Cardiology: State of the art and future directions. *Clinical Nuclear Cardiology: State of the art and future directions.* . 3rd ed: Elsevier Mosby; 2005: p180.
17. Chuang ML, Lin IF, Hsieh MJ. More Impaired Dynamic Ventilatory Muscle Oxygenation in Congestive Heart Failure than in Chronic Obstructive Pulmonary Disease. *J Clin Med.* 2019;8(10):pii: E1641.
18. Stringer W, Hansen JE, Wasserman K. Cardiac output estimated noninvasively from oxygen uptake during exercise. *J Appl Physiol.* 1997;82(3):908-912.
19. Katz SD, Maskin C, Jondeau G, Cocke T, Berkowitz R, LeJemtel T. Near-maximal fractional oxygen extraction by active skeletal muscle in patients with chronic heart failure. *J Appl Physiol.* 2015;88(6):2138-2142.
20. Zelt JT, Jones JH, Hirai DM, et al. Systemic vascular dysfunction is associated with emphysema burden in mild COPD. *Respir Med.* 2018;136:29-36.
21. O'Donnell DE, Elbehairy AF, Berton DC, Domnik NJ, J.A. N. Advances in the Evaluation of Respiratory Pathophysiology during Exercise in Chronic Lung Diseases. *Front Physiol.* 2017;8:82.
22. Chuang ML, Huang SF, Su CH. Cardiovascular and respiratory dysfunction in chronic obstructive pulmonary disease complicated by impaired peripheral oxygenation. *Int J Chron Obstruct Pulmon Dis.* 2015;10:329-337.

106年度專題研究計畫成果彙整表

計畫主持人：莊銘隆	**計畫編號：**106-2314-B-040-025-
計畫名稱：漸增式極限運動時的氧脈衝型態研究-於正常人、慢性阻塞性肺病人與心衰竭病人的差異研究 －可能的機轉	

成果項目					量化	單位	質化（說明：各成果項目請附佐證資料或細項說明，如期刊名稱、年份、卷期、起訖頁數、證號...等）
國內	學術性論文	期刊論文			0	篇	
		研討會論文			0		
		專書			0	本	
		專書論文			0	章	
		技術報告			0	篇	
		其他			0	篇	
	智慧財產權及成果	專利權	發明專利	申請中	0	件	
				已獲得	0		
			新型/設計專利		0		
		商標權			0		
		營業秘密			0		
		積體電路電路布局權			0		
		著作權			0		
		品種權			0		
		其他			0		
	技術移轉	件數			0	件	
		收入			0	千元	
國外	學術性論文	期刊論文			0	篇	
		研討會論文			0		
		專書			0	本	
		專書論文			0	章	
		技術報告			0	篇	
		其他			0	篇	
	智慧財產權及成果	專利權	發明專利	申請中	0	件	
				已獲得	0		
			新型/設計專利		0		
		商標權			0		
		營業秘密			0		
		積體電路電路布局權			0		
		著作權			0		
		品種權			0		

		其他	0		
	技術移轉	件數	0	件	
		收入	0	千元	
參與計畫人力	本國籍	大專生	1	人次	1位學士研究生
		碩士生	2		2位碩士研究生
		博士生	0		
		博士級研究人員	0		
		專任人員	3		3位兼任研究助理
	非本國籍	大專生	0		
		碩士生	0		
		博士生	0		
		博士級研究人員	0		
		專任人員	0		
其他成果 （無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。）					

科技部補助專題研究計畫成果自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現（簡要敘述成果是否具有政策應用參考價值及具影響公共利益之重大發現）或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估
   □達成目標
   ■未達成目標（請說明，以100字為限）
   　□實驗失敗
   　□因故實驗中斷
   　■其他原因
   說明：
   人數收案未如預期,原本預計兩年收200位受試者。本研究共篩選190位,只收82位納入分析。

2. 研究成果在學術期刊發表或申請專利等情形（請於其他欄註明專利及技轉之證號、合約、申請及洽談等詳細資訊）
   論文：□已發表　□未發表之文稿　■撰寫中　□無
   專利：□已獲得　□申請中　■無
   技轉：□已技轉　□洽談中　■無
   其他：（以200字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性，以500字為限）
   以往用O2P的值作為判斷心血管系統在運動中是否正常,但本研究則不支持此說法,反而用O2P的型態可以。O2P型態分析有其獨特的結果,對於使用運動心肺功能做測試的研究者或臨床者,提供一個判讀的參考。另外,本研究也間接否認肌肉對氧氣的攫取量,不論在正常人、COPD、CHF病人都一樣的說法,往後對這類檢查或研究,皆應修正以前的概念。

4. 主要發現
   本研究具有政策應用參考價值：■否　□是，建議提供機關
   （勾選「是」者，請列舉建議可提供施政參考之業務主管機關）
   本研究具影響公共利益之重大發現：□否　□是
   說明：（以150字為限）